Industrial QUALITY CONTROL

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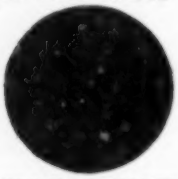

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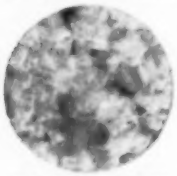

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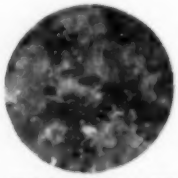

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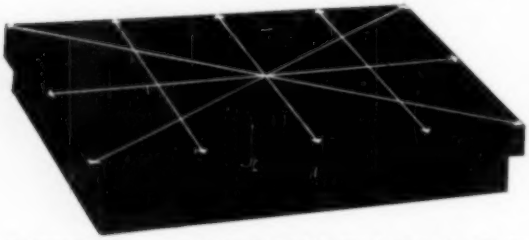

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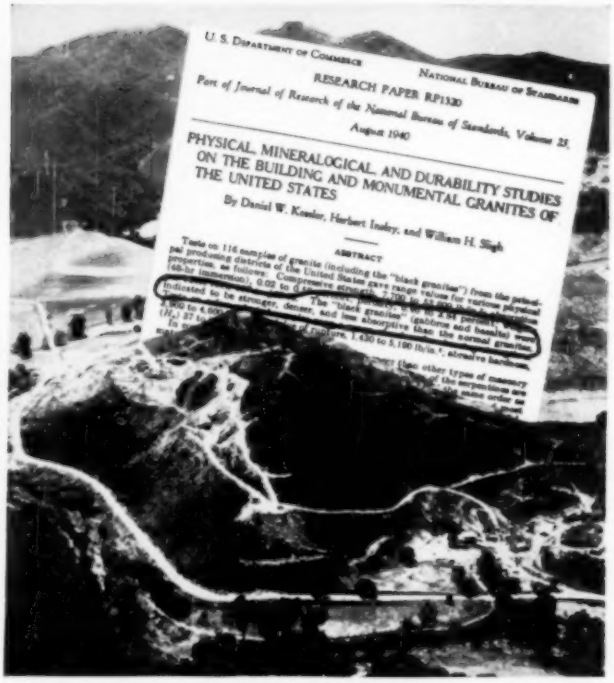
U. S. Department of Commerce
National Bureau of Standards
Research Paper RP1320
Part of Journal of Research of the National Bureau of Standards, Volume 25, August 1940
PHYSICAL, MINERALOGICAL, AND DURABILITY STUDIES ON THE BUILDING AND MONUMENTAL GRANITES OF THE UNITED STATES
By Daniel W. Kessler, Herbert Insley, and William H. Sligh
Abstract

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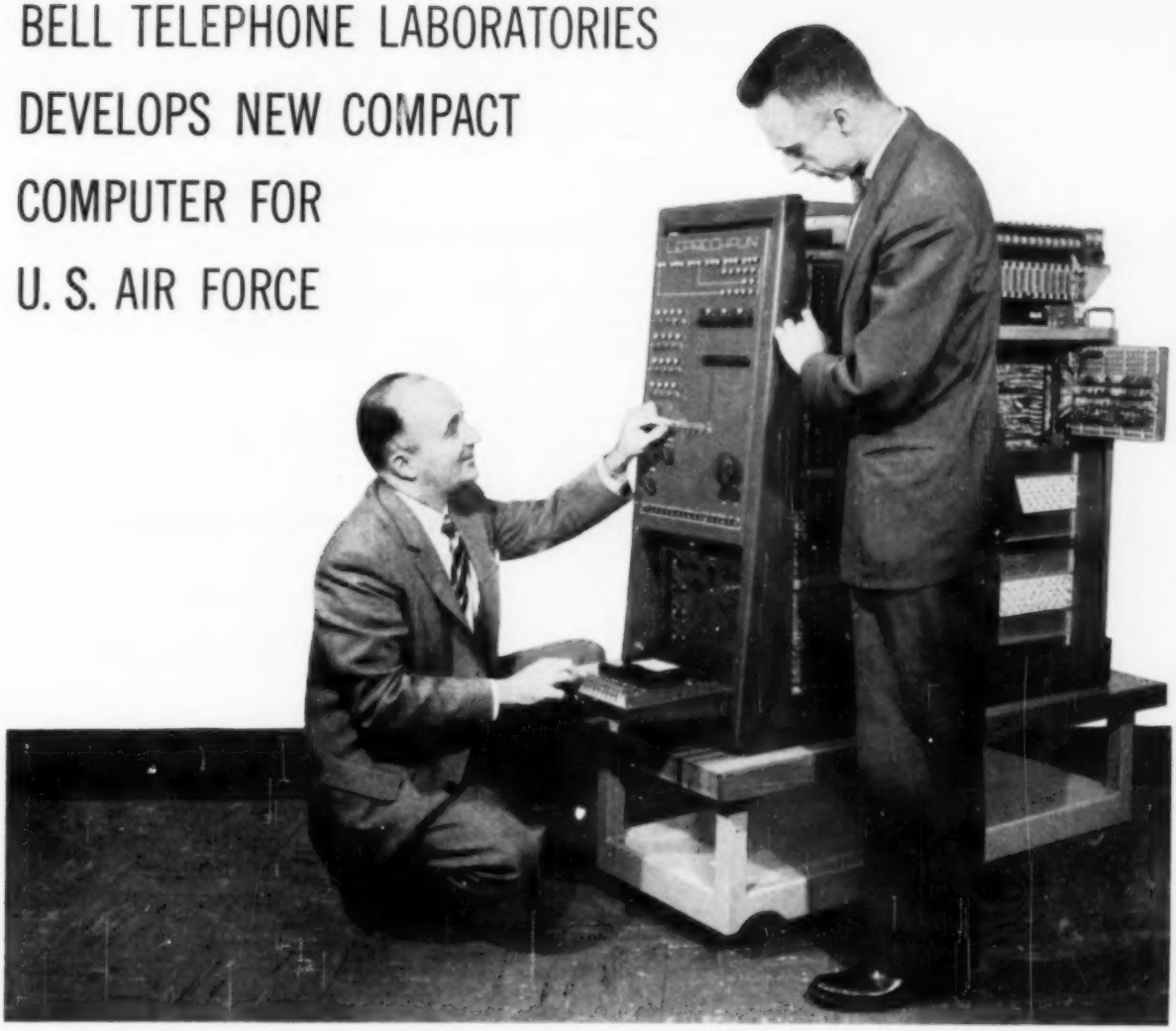

J. A. Githens, B.S. in E.E., Drexel Institute of Technology, and J. A. Baird, Ph.D. in E.E., Texas A. & M., check the control panel of Leprechaun, a new high-speed computer which solves extremely complex problems in one-tenth of a second. Small size and low power are made possible by new design principles and Bell Laboratories' invention of the transistor.

The United States Air Force assigned Bell Labs an interesting assignment: develop a new kind of electronic computer. The major requirement was greater simplicity. Of course, no computer is simple, but this one (known as "Leprechaun" to its designers) is much smaller and simpler than most of the computers currently in use.

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From the President's Desk

Quality Control International

Many recent international developments are important for those of us in quality control. The appearance of Sputnik I and II has dramatized the need for expanded research and development, and for increased reliability. There is new emphasis on the need for pooling our information with our allies. Fortunately ASQC anticipated the need by establishing a Committee on International Cooperation in 1956.

Many of our members have promoted quality control internationally. The pioneer of course was Dr. Walter A. Shewhart, and the list of those who have conducted seminars or served as technical assistance consultants overseas includes Clifford, Deming, Enell, Hamby, Juran, Kramer, Littauer, MacNiece, Ott, Seder. Wescott and Wilks. Many others have taken part in international meetings. The countries include all of Free Europe, Australia, Egypt, India, Israel, Japan, Mexico and Pakistan.

Beginning under the Marshall Plan and continuing under the International Cooperation Administration, we have had an extensive exchange program. European teams have visited our factories and universities, Japan is sending one in January.

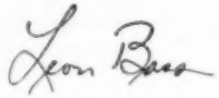
At present there are Societies for Quality Control in Germany, France, Italy, the Netherlands, Scandanavia, India and Japan, each of which now publishes a journal. The British Productivity Council is promoting one in England. These Societies have formed a European Organization for Quality Control and held the First International Congress on Quality Control in Paris in July, 1957, with ASQC participation. The International Statistical Institute publishes the International Journal of Abstracts on Statistical Methods in Industry.

ASQC has a limited but influential membership abroad. We have one section in Japan, another in Mexico, and an International Section with 75 members from 18 countries, many of whom are officers and editors of the various national societies. This is our newest section and indications are that despite the dollar exchange problem we can expect considerable growth.

The ASQC Committee on International Cooperation has the responsibility of Maintaining contact and serving as the channel of communication and liaison between ASQC and similar societies and groups outside North America. The committee arranges the exchange of publications, cooperates in planning programs for visitors to and from these countries and coordinates with such agencies as the International Administration and United Nations. The Chairman of the Committee also serves as trustee for the International Section.

To meet its responsibilities, the Committee needs the cooperation of many members of the Society. ASQC members who are visiting foreign countries and are willing to address groups there are urged to inform the Committee of their plans. Visitors from abroad who want to observe quality control in industry benefit from personal contacts. The most effective communication is person-to-person, and one function of the committee is to get the right people communicating.

Sincerely,



Economy in the Planning of Experiments

One of the typical problems confronting both the experimental scientist and research worker in industry is that of evaluating the joint effects of several different factors on a given material or process. Other things being equal, the smaller the number of factors the fewer the difficulties encountered. Because of possible complex interactions among the various factors, however, the difficulties become formidable for even a relatively moderate number of factors. Problems of this kind have often had to be dismissed as too difficult, although occasional brilliant results were achieved by scientists gifted with unusual insight or sound judgment gained through long experience. The recent growth of the subject of experiment design has occurred in response to the need for more systematic and reliable methods, a need created by the growing scope and complexity and industrial activity.

The first broad classes of experiment designs, made possible by advances in statistical theory, were devised to fit the special problems of agricultural research. Somewhat later, efforts were made to adapt these experimental procedures for use in physical science, engineering, and industry. At the National Bureau of Standards the study of these problems forms a major part of the research program of the NBS Statistical Engineering Laboratory. The latest results obtained by the Laboratory, in research supported partly by the Chemical Corps, Department of the Army, should lead to material savings in time and effort for experimenters faced with multi-factor problems. These results, which relate to an important class of experiment designs, are described and catalogued in the NBS publication, *Fractional Factorial Experiment Designs for Factors at Two Levels.*[1]

Editorial Note

The material published herewith represents a Summary Technical Report prepared by the National Bureau of Standards, Department of Commerce, and distributed only to a selected list of editorial personnel. Since copies of this report are not available on an individual request basis, and since permission to publish has been granted, it is presented to *Industrial Quality Control* readers with the expectation that they will find it useful and interesting.

One way to approach a multi-factor problem is to make measurements with all factors except one fixed, and afterwards to repeat this process for each of the factors. Conclusions are then drawn concerning the effect which each factor has on the measurements. When the various factors are interdependent, however, the "one factor at a time" procedure may lead to erroneous results. R. A. Fisher[2] has shown that the most efficient way to conduct multi-factor experiments is to make measurements at all possible combinations of the factors involved.

Nevertheless, even for a relatively small number of factors, the number of possible experimental combinations may more than tax the available facilities. Also, in many situations it is not practical to plan an entire experimental program in advance, but rather to conduct a few smaller experiments which serve as a guide to future work. Or, more generally, it may be that not all of the information or precision which a complete set of experiments could give is needed for the purpose in hand.

Several statisticians, notably Finney and Kempthorne,[3] have recently considered the problem of planning multi-factor experiments that require measuring only a fraction of the total number of possible combinations. The experiment designs that have resulted are known as "Fractional Factorial" designs. These not only save experimental effort, but they also make the analysis relatively straightforward.

The result of the Bureau's studies along these lines has been to make the theory of fractional designs more immediately accessible to the working scientist. The new publication, prepared by the Statistical Engineering Laboratory,[2] catalogues experiment designs in which the number of factors range from 7 to 16, with all factors allowed two different conditions. For problems with these general characteristics, the experimenter can choose from among procedures requiring only $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$, $\frac{1}{32}$, $\frac{1}{64}$, $\frac{1}{128}$, or $\frac{1}{256}$ of all possible experimental combinations.

An industrial chemical process, for example, may depend on the commercial grade of the principal reactant, the source from which the reactant is obtained, the amount and concentration of acid used, and the pressure, temperature, and time of reaction. Suppose it is desired to study the effects on the characteristics of the final product when these seven factors are varied; and assume that it is sufficient to consider only two alternatives in connection with each factor, so that there are two commercial grades of reactant, two concentrations of acid, and so forth. Since there are seven factors and each may exist in two different conditions, there are $2^{(7)}$ or 128 possible

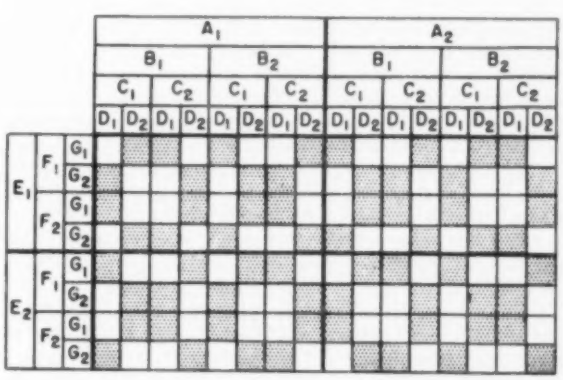


Figure 1—Fractional factorial experiment plan requiring only 64 of the 128 possible measurements

experimental combinations. A "complete factorial design" would prescribe the making of all 128 of these experiments.

However, it may not be practical to perform all of the experiments. Possibly, also, one may not need all the information such a complete factorial procedure could provide. It is at this point that assistance may be obtained from the experiment designs described in the Bureau's publication.

In the example given, let the letters A, B, C, D, E, F, G stand for the seven factors, and let the subscripts 1 and 2 denote the two alternative conditions in which each of the factors may exist. Then the 128 possible experimental combinations are represented by the 128 cells of Fig. 1. The shaded squares represent those experimental combinations to be investigated if the experimenter wishes to measure only half of the possible 128 combinations. In the same way, Figures 2 and 3 illustrate plans requiring only 36 and 16 measurements, respectively, instead of the full set of 128.

Naturally, the more measurements taken, the greater the resulting information and the greater the precision. The experimental plan calling for ⅛ of the possible combinations can only be used for evaluating the broad effects of each of the seven factors. The ¼-plan, in addition, allows the interdependence of some of the factors to be determined. The latter plan could be of use, for example, when there is independent information indicating that the interaction between certain of the factors is negligible. The ½-plan (Fig. 1), on the other hand, not only provides information on the broad effects of each of the seven factors, but also permits evaluation of the interdependence among *all* of those factors. The only price paid for this information is a loss in precision. In many cases, especially in industrial experiments, this loss is more than compensated for by the saving in time and expense.

Figure 2—Fractional factorial experiment plan requiring only 32 of the 128 possible measurements

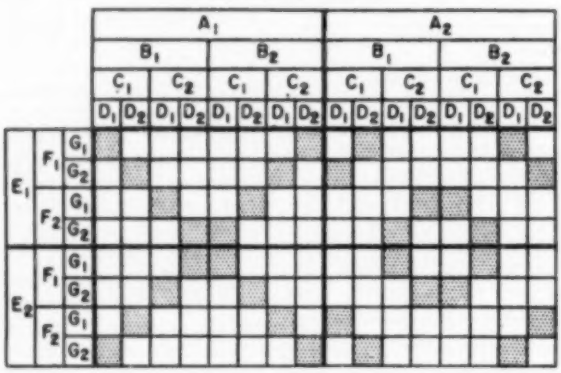
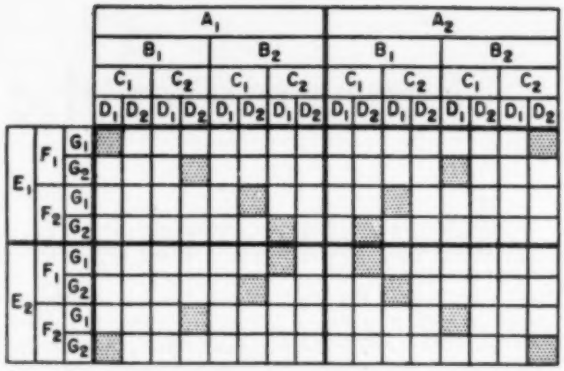


Figure 3—Fractional factorial experiment plan requiring only 16 out of 128 possible measurements



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(1) *Fractional Factorial Experiment Designs for Factors at Two Levels*, National Bureau of Standards Applied Mathematics Series 48, 1956, available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

(2) Fisher, R. A., *The Design of Experiments*, Oliver and Boyd, Ltd., Edinburgh, 1949.

(3) Finney, D. J., "The Fractional Replication of Factorial Arrangements," *Ann. of Eugenics*, 12, 291 (1945)
Kempthorne, O., "A Simple Approach to Confounding and Fractional Replication in Factorial Experiments, *Biometrika*, 34, 255 (1947)

Introduction

R. A. Fisher[7] in 1936 introduced the discriminant function for the comparison of multiple measurements observed in *taxonomic* studies. Since then several articles [1,2,4,5,6,8] have appeared that use this statistical technique for various purposes. During the last five years ideas pertaining to this type function have been presented in elementary statistical textbooks [9,10]. A discriminant function enables one to compare a composite composed of several variables pertaining to one "treatment" with a similar composite pertaining to another.

An application of this function was made for the differentiation of two series of proximate coal analyses and the b.t.u. per pound. These analyses included volatile matter, fixed carbon, percent of ash, and b.t.u. per pound which were used in making a comparison of coal from two mines. A discriminant function enables one to obtain a numerical comparison of the coals by use of two linear compounds made up of the four variables [1].

Two types of fabrics were tested for investigating a significant difference between them by a discriminant function by comparing the difference between two compounds made up of the five variables breaking strength of warp, breaking strength of filling, warp shrinkage, filling shrinkage, and percent of absorption[3].

Testing for Three Methods of Preparing Fish

This article is concerned with an application of discriminant functions for differentiating between a series of judges' scores made on fish prepared by three methods. Three lots, each of twelve fish, were prepared by methods A, B, and C. Five experienced judges ate samples of each fish and graded each for aroma, flavor, texture, and moisture. The average score for aroma of the five judges was recorded as the aroma score for the particular fish. Similarly averages of the judges' scores were used for flavor, texture, and moisture. In this way

individual differences between judges were somewhat ironed out of the results. Judges were not aware of the methods of preparing the fish and never knew which preparation was used for any particular sample. Table I contains the individual judge's scores together with their averages.

Questions arose as to whether or not there were significant differences between scores, taken altogether, pertaining to the four characteristics of the fish prepared by two methods. Before the derivation of discriminant functions it was necessary to determine whether or not aroma averages pertaining to two methods were significantly different, then to determine whether or not flavor averages were different, etc. Discriminant functions enable one to test for significance between two recipes by using, respectively, compounds or linear equations made up of scores pertaining to each recipe. They have been called discriminant functions because they discriminate between the two sets of samples by using *all* the measurements of *each* characteristic (aroma, flavor, texture and moisture.)

Using Discriminant Functions to Analyze Test Data

Let the compound for method A be

$$X = b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4,$$

where x_1, x_2, x_3 and x_4 represent, respectively, scores pertaining to aroma, flavor, texture, and moisture, and where b_1, b_2, b_3 and b_4 are constants to be found.

Let the compound for method B be

$$X' = b_1x_1' + b_2x_2' + b_3x_3' + b_4x_4'.$$

Compounds X and X′ are, respectively:

$$X = -0.05562x_1 + 0.20205x_2 - 0.03729x_3 - 0.04065x_4$$

$$X' = -0.05562x_1' + 0.20205x_2' - 0.03729x_3' - 0.04065x_4'$$

The means of these compounds are:

$$\overline{X} = -0.05562(5.38) + 0.20205(5.71) - 0.03729(5.44) - 0.04065(5.98) = 0.4085$$

$$\overline{X'} = -0.05562(5.26) + 0.20205(5.23) - 0.03729(5.30) - 0.04065(5.87) = 0.3279$$

The difference between the means of these compounds is D = 0.0806.

Comparing Methods A and B

It is natural to ask whether or not this difference between the two compound means, which are made up of scores pertaining to aroma, flavor, texture, and moisture, is due to fluctuations of random sampling, or to a real difference between methods A and B? This question is answered in Table II, which contains an analysis of variance between these compound means $\overline{X}$ and $\overline{X'}$. The ratio of the between compound means-mean squares and the error-mean square is 2.30, which is an F-value. Since this F-value is less than the F-value of 2.90 found in an F-table at 4 and 19 degrees of freedom, the compound mean $\overline{X}$ is not significantly different from X′ at the 5 percent level.

TESTING FOR DIFFERENCES

between methods of preparing fish by use of a discriminant function*

W. D. BATEN, P. I. TACK, AND HELEN A. BAEDER†

where x_1', x_2', x_3' and x_4' represent, respectively, similar scores pertaining to method B. The b's are the same in both compounds. The difference between means of the compounds is, $D = \overline{X} - \overline{X'}$, and is equal to

$$D = b_1d_1 + b_2d_2 + b_3d_3 + b_4d_4,$$

where d_1 represents the difference between means of aroma scores for methods A and B, d_2 represents the difference between averages pertaining to flavor, d_3 represents the difference between averages of texture, and d_4 represents the difference between averages of methods A and B pertaining to moisture.

By using statistical techniques explained in Fisher's first article[7] and explained in the Appendix to this present article, values of b_1, b_2, b_3 and b_4 were found to be $b_1 = -0.05562$, $b_2 = 0.20205$, $b_3 = -0.03729$, and $b_4 = -0.04065$.

This means, as far as these four characteristics are concerned, that method A is very probably not any better than method B, although the averages of the judges' scores for the former are respectively larger than those for the latter.

Comparing A to C and B to C

If compound X is divided by the least coefficient in it, (0.03729), it becomes

$$X = -1.4916x_1 + 5.4183x_2 - 1.0000x_3 - 1.0901x_4 \quad [1]$$

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By carrying out a similar analysis on the four sets of scores for methods A and C, the value of D, the discriminant function, is

$$D = -0.0081 + 0.7345 + 0.1826 + 0.0551 = 0.9641.$$

An analysis of variance, not given, reveals that there is a significant difference between method A and method C. The sizes of the terms in the equation for D pertaining to methods A and C indicate the importance of the characteristics of the fish for discriminating between the two methods. The second term, 0.7345, is the largest in absolute value; hence, flavor was the most important characteristic in the minds of the judges for distinguishing a difference. The third term, 0.1826, is next largest in absolute value; hence, desirability of texture was next in importance for distinguishing a difference. The score of third importance was moisture; the last of importance was that of aroma.

By carrying out a similar analysis on the scores pertaining to methods B and C, the value of D was found to be

$$D = 0.0131 + 0.1200 + 0.2116 - 0.0070 = 0.3377.$$

An analysis of variance showed that method B also was different from method C. The sizes of the absolute values of the terms in D show that desirability of texture was the most important factor for distinguishing differences between these two methods. Flavor was next in importance, moisture was third, while aroma was again last. The ranks of the importance of the various factors or characteristics depend upon the judges' scores, which are determined by the individual fish. These ranks may change, as has been shown.

Conclusion

By use of a discriminant function made up of scores on four characteristics (desirability of aroma, flavor, texture and moisture) it was possible to test for significance between methods of preparing fish and also to ascertain the ranks of importance of the characteristics.

Discriminant functions thus give a test for comparing compounds made up of several variables. They can be helpful to research workers in foods and nutrition for detecting differences which involve two or more factors in combination. This type of statistical analysis is a powerful and useful tool, for it enables one to compare composites made up of all characteristics. Desirability of one method of preparing fish was judged by the way aroma, flavor, texture, and moisture together entered into each judge's decision pertaining to the two methods. The judges scored on separate factors; the discriminant function furnishes a score on a composite of all these seperate factors taken together.

Appendix

1. Finding the Discriminant Function Constants

The method of obtaining the constants in the linear compounds will be explained here.

$$\text{Let } S = b_1^2S_{11} + b_2^2S_{22} + b_3^2S_{33}^2 + b_4^2S_{44} + 2b_1b_2S_{12} + 2b_1b_3S_{13} + 2b_1b_4S_{14} + 2b_2b_3S_{23} + 2b_2b_4S_{24} + 2b_3b_4S_{34},$$

$$\text{where } S_{ij} = \sum_{k=1}^{12} (X_{ik} - \overline{X}_i)(X_{jk} - \overline{X}_j) + \sum_{k=1}^{12} (X'_{ik} - \overline{X}'_i)(X'_{jk} - \overline{X}'_j)$$

The value of S_{ij} when $i = 1$ and $j = 1$ is

$$S_{11} = \sum_{k=1}^{12} (X_{1k} - \overline{X}_1)^2 + \sum_{k=1}^{12} (X'_{1k} - \overline{X}'_1)^2.$$

For the data in Table I this quantity is found as follows:

$$\begin{aligned} S_{11} &= (5.4 - 5.38)^2 + (5.2 - 5.38)^2 + \ldots \\ &\quad + (5.3 - 5.38)^2 + (5.0 - 5.26)^2 \\ &\quad + (4.8 - 5.26)^2 + \ldots + (5.1 - 5.26)^2 \\ &= 3.76 + 6.41 = 10.17 \end{aligned}$$

The value of S_{ij} when $i = 2$ and $j = 3$ is

$$S_{23} = \sum_{k=1}^{12} (X_{2k} - \overline{X}_2)(X_{3k} - \overline{X}_3) + \sum_{k=1}^{12} (X'_{2k} - \overline{X}'_2)(X'_{3k} - \overline{X}'_3).$$

From Table I this becomes

$$\begin{aligned} S_{23} &= (6.0 - 5.71)(6.3 - 5.44) \\ &\quad + (6.2 - 5.71)(6.0 - 5.44) + \ldots \\ &\quad + (5.9 - 5.71)(5.8 - 5.49) \\ &\quad + (5.3 - 5.23)(5.3 - 5.30) \\ &\quad + (4.9 - 5.23)(4.2 - 5.30) + \ldots \\ &\quad + (4.9 - 5.23)(5.3 - 5.30) \\ &= 2.53 + 2.75 = 5.28 \end{aligned}$$

Table I—Scores on Aroma, Flavor, Texture, and Moisture Pertaining to Fish Prepared by Methods A, B and C

A				B				C			
Aroma	Flavor	Texture	Moisture	Aroma	Flavor	Texture	Moisture	Aroma	Flavor	Texture	Moisture
5.4	6.0	6.3	6.7	5.0	5.3	5.3	6.5	4.8	5.0	6.5	7.0
5.2	6.2	6.0	5.8	4.8	4.9	4.2	5.6	5.4	5.0	6.0	6.4
6.1	5.9	6.0	7.0	3.9	4.0	4.4	5.0	4.9	5.1	5.9	6.5
4.8	5.0	4.9	5.0	4.0	5.1	4.8	5.8	5.7	5.2	6.4	6.4
5.0	5.7	5.0	6.5	5.6	5.4	5.1	6.2	4.2	4.6	5.3	6.3
5.7	6.1	6.0	6.6	6.0	5.5	5.7	6.0	6.0	5.3	5.8	6.4
6.0	6.0	5.8	6.0	5.2	4.8	5.4	6.0	5.1	5.2	6.2	6.5
4.0	5.0	4.0	5.0	5.3	5.1	5.8	6.4	4.8	4.6	5.7	5.7
5.7	5.4	4.9	5.0	5.9	6.1	5.7	6.0	5.3	5.4	6.8	6.6
5.6	5.2	5.4	5.8	6.1	6.0	6.1	6.2	4.6	4.4	5.7	5.6
5.8	6.1	5.2	6.4	6.2	5.7	5.9	6.0	4.5	4.0	5.0	5.9
5.3	5.9	5.8	6.0	5.1	4.9	5.3	4.8	4.4	4.2	5.6	5.5
Ave. 5.38	5.71	5.44	5.98	5.26	5.23	5.30	5.87	4.97	4.83	5.90	6.23

TABLE II—Analysis of Variance of the Compounds Composed of the Four Sets of Scores; $N_1 = N_2 = 12$

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square
Total	23		
Between compound means	4	$\frac{N_1N_2}{N_1+N_2} D^2 = 0.0390$	0.009750
Within or Error	19	$D = 0.0806$	0.004242

The quantity S is equal to the sum of squares within compounds. By minimizing the quantity D^2/S, the following equations arise:

$$S_{11}b_1 + S_{12}b_2 + S_{13}b_3 + S_{14}b_4 = d_1$$
$$S_{12}b_1 + S_{22}b_2 + S_{23}b_3 + S_{24}b_4 = d_2$$
$$S_{13}b_1 + S_{23}b_2 + S_{33}b_3 + S_{34}b_4 = d_3$$
$$S_{14}b_1 + S_{24}b_2 + S_{34}b_3 + S_{44}b_4 = d_4$$

where the S_{ij} −values are defined above and $d_i = \overline{X}_i - \overline{X}'_i$, $i = 1, 2, 3, 4$.

For the above scores these equations become:

$$10.165834b_1 + 5.638334b_2 + 6.972500b_3 + 4.644167b_4 = 0.12500$$
$$3.638334b_1 + 5.775834b_2 + 5.272650b_3 + 4.471667b_4 = 0.475000$$
$$6.972500b_1 + 5.272650b_2 + 8.738334b_3 + 5.370833b_4 = 0.133334$$
$$4.644167b_1 + 4.471667b_2 + 5.370833b_3 + 8.279167b_4 = 0.108333$$

from which the b's were found to be

$$b_1 = -0.05562,\ b_2 = 0.20205,\ b_3 = -0.07329,$$
$$b_4 = -0.04065$$

When the compounds X and X' are used to secure composite scores for the various fish used in method A and method B, the following values are obtained: *

Method A Composite Scores	Method B Composite Scores
4.05	3.31
5.04	3.39
3.45	2.24
3.57	3.93
4.23	3.37
4.23	3.21
4.18	2.35
4.35	2.59
3.88	4.48
3.02	3.93
4.56	3.43
4.37	3.13
Ave. 4.08	3.28

*Scores in this table were obtained by multiplying the composite scores by 10.

If an analysis of variance is carried out on these composite scores, the F-value will be the same as that obtained in Table II, provided the degrees of freedom are the same as those in Table II.

Comparison with Linear Regression

The compounds X and X' are similar to a predicting equation between a criterion y and the aroma-, flavor-, texture-, and moisture-scores of the judges where y is equal to one for each of the composite scores for the fish prepared by method A and equal to zero for each of those prepared by method B. This criterion y may be written as

$$y = c_0 + c_1x_a + c_2x_f + c_3x_t + c_4x_m,$$

where x_a represents aroma scores, x_f represents flavor scores, x_t represents texture scores, and x_m represents moisture scores, and where the c's are to be found by the method of least squares in ordinary multiple regression. The x's represent scores pertaining to both methods A and B.

The usual variance and covariance calculations are, in part:

$$\Sigma(x_a - \overline{x}_a)^2 = \Sigma x_1^2 + \Sigma x'^2_1 - \frac{(\Sigma x_1 + \Sigma x'_1)^2}{24}$$
$$= 10.259583$$
$$\Sigma(x_a - \overline{x}_a)(x_f - \overline{x}_f) = \Sigma x_1x_2 + \Sigma x'_1 x'_2 - \frac{(\Sigma x_1 + \Sigma x'_1)(\Sigma x_2 + \Sigma x'_2)}{24}$$
$$= 5.994583, \text{ etc.}$$
$$\Sigma(x_a - \overline{x}_a)(y - \overline{y}) = \frac{\Sigma x_1 - \Sigma x'_1}{2}, \text{ etc.}$$

Solving the normal equations arising in the least squares method, the following equation arises:

$$y = -0.993831 - 0.22582x_a + 0.82028x_f - 0.15135x_t - 0.16506x_m.$$

After dividing by the smallest coefficient, 0.15135, this becomes

$$Z = -1.4920x_1 + 5.4197x_2 - 1.0000x_3 - 1.0906x_4 - 6.56640,$$

which is similar to composite [1].

If an analysis of variance is carried out for this regression, the following is obtained:

Source	D.F.	SS	S.Sq.	F
Total	23	6		
Regression	4	1.94	0.485	2.27
Residual Error	19	4.06	0.214	

The F-value is practically equal to the F-value in Table II.

For the similarity between a discriminant function and linear regression see Garrett[8].

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Quality Control Comes of Age

WILLIAM M. BRISTOL, III

Bristol-Myers Products Division, Hillside, N. J.

Bristol-Myers was founded in 1887 in Clinton, N. Y., for the purpose of serving the druggist with about 4000 medicinal items. These were prepared upon receipt of an order from a druggist and prepared in small quantities under the direct supervision of the founder. The organization was necessarily a small one, and all functions were directly controlled by one or two individuals. Quality control as a science was still unknown. As the organization grew, we needed more space and moved to Brooklyn. There we continued to expand until 1919, when a decision was reached that the company needed much larger quarters, and we moved to Hillside, N.J., in what was eventually to become the large white buildings we now occupy along U.S. Route No. 22.

As we grew, we gradually lost our identity as compounders of many items for the drug trade and began to concentrate on fewer products. With the emphasis on fewer products, we developed the idea of selling directly to a druggist or a retail store a product which, in turn, could be sold directly over-the-counter to a consumer. By 1925, the transition was almost complete and we had generally taken on the form that the Products Division of Bristol-Myers has today.

As the company expanded, it became imperative for top management to spend more and more time away from the actual production of the products and, therefore, it became necessary to delegate some of those responsibilities to other people. Where we had been selling a few bottles of a product to a druggist, we were now selling millions of units of each product over-the-counter to be used by the ultimate consumer.

During our history, we had been rather proud of the fact that we felt we could guarantee the quality of our products. In fact, we had developed much of our business on the premise that Bristol-Myers would unqualifiably guarantee the excellence of its products. It was inevitable that eventually management would ask itself the following question:

> "How do we know that the quality of our products is being maintained with the large volume increases that have been gained over the past years?"

The answer to this question was that we must necessarily continue to guarantee the quality of our products. This responsibility was assigned to our Research Department, which, in turn, assigned the responsibility for quality control to one or two people in that department. However, there was insufficient emphasis and prestige attached to this function.

As World War II developed, new techniques were constantly being devised to control production quality. Several of our management people were asked to assume responsibilities in defense operations, and were exposed to the need for quality control in products used by the Armed Services.

At the close of the war, our company became very conscious of the need for additional controls, not only on the finished product, but on the packaging materials and raw materials used in compounding the product. After considerable discussion and planning, it was decided that we needed a separate department in our company whose sole responsibility would be the quality control of our materials, so that we could assure our customers and ourselves that the products prepared in our plant were of uniformly good quality.

The few people who were assigned to quality control work in the Research Department were then separated, and a department was organized independent of Research and Development, and independent of Production. This group was authorized to develop a Control Department which would report to top management and which would have the responsibility for determining whether or not our products were suitable for sale.

Today, we have grown from such beginnings to an organization which has a well-established quality control department, and an organization which fully recognizes the need for quality control of our products.

Now we come to another relatively new science, which is closely allied to quality control, but which utilizes a unique approach to determine the quality of the product. As the number of unit packages of a product grows from the hundreds of thousands, to the millions, to the tens and hundreds of millions, it becomes literally impossible to interpret individually the results of sampling without using techniques different from those that had been available previously. We were aware of this problem some years ago and cast about for a means of using other techniques which would limit our risk.

Again, the growth of statistics in World War II, particularly by the Armed Services, pointed to a direction which we felt was helpful. Our quality control people were asked to investigate these techniques, and after some study, a recommendation was made to management that a statistical approach to quality control could be helpful.

♦ ♦ ♦

At this point a word of explanation about our company's growth during the past fifteen or twenty years is in order.

During World War II, our management appreciated the country's need for having additional supplies of certain (then rare) medicines, and we bought a small drug company, which was renamed Bristol Laboratories, and which was located in Syracuse, N.Y.

The primary object of this plant was to produce penicillin and other antibiotics for the Armed Services. At the close of the war, it was necessary for us to expand the activities of the plant into other products related to the ethical drug field, and today Bristol Laboratories is at or near the top in antibiotic production.

Contact with the Armed Forces exposed Bristol Laboratories to the new techniques in the use of statistics. The importance and value of statistical quality control was dramatically proven at Bristol Labs. I was most fortunate in observing first hand the contribution that these techniques made, not only to cost reduction (always desirable), but more importantly to improved quality of production. Armed with this experience, we determined to establish a similar system in our Products Division. We were guided in this effort by advice and assistance from the staff of our neighbor, Rutgers University, as well as from our own Bristol Laboratories. These advisers did not promise us "the moon," but the results of their efforts were so electrifying that I suspect their chief problem became one of holding the reins on management's impatience to expand the program. To their great credit was their well thought out approach to all personnel, especially those below the management level. For, just as the "buck privates" win the war, so also do the line operators, processors, and mechanics win the struggle for improved quality. I suspect all of you are well aware of this oft-misunderstood fact. In short, the use of the statistical approach showed us a simpler means to greater assurance of the acceptability of our goods.

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As most of you know, statistical quality control has been used by the government, the Armed Services, and many of the machine parts manufacturers for many years. Today, all industries are recognizing the importance of statistical control, not only in the actual production operation, but in sales, advertising, accounting, and market research as well. Statistical quality control has been used at Bristol-Myers, particularly along three lines:

A. Statistical sampling plans for incoming raw and packaging materials.
B. Control chart applications in filling weight control.
C. Experimental design in investigational and experimental work.

You represent many of the largest industries in our country. Most of you, I am sure, have no doubts in your minds that statistical quality control is most important to the success of your companies. I agree with you. "BUT," you may query, "how can I impress my management with the importance of my job and the need for my skills?" As a member of management in our company, I can appreciate your position, since each department of every company is asking itself this same question. "How can I better impress my management with the importance of my function to the success of my company?" Possibly you scientists are particularly well equipped to do such a job. However, a general speech on the value of statistical quality control will not particularly impress top management.

BUT—if you were to go to management using this particular approach:

"Our product X is awful!"

"It is impossible with our present type of production to assure a customer that he is getting any uniformity in the product!"

"The product is not doing what it is designed to do," I am sure that such an approach would make any company official sit up and listen. Parenthetically, I should add that the precise form in which you make these statements to management will depend upon your judgment of what will be most effective. If you can then tell your management what is wrong with the product, and tell them how the product could be improved and controlled so that production would be uniform, and the ingredients so mixed that production would operate at its maximum efficiency, I am sure that your management would be vitally interested.

Naturally, before such a step is taken, you must be certain of your facts and figures, and you must be able to demonstrate with specific examples how you propose to improve the situation.

As short a time as fifteen years ago, both quality control as such, and certainly statistical quality control, were almost in their infancy. Today, there are very few progressive companies of any size or importance which do not have quality control departments that are well-staffed and, in general, well run.

Management today appreciates the need for quality control and recognizes the job which is being done by the statisticians in quality control. Perhaps management does not as yet fully appreciate the efforts that many of you people are putting into your jobs, but they will. However, it will be up to you as individuals to sell your own companies on the job you are doing, and how you can better aid your management in improving the quality and the quantity of output.

Let me close by pointing out management's philosophy toward a statistical quality control department. Certainly, it does not make a product in the literal sense; certainly, it does not protect a product; it adds nothing to the value of the product; certainly, it does not transport a product. It is strictly an overhead type of operation. However, it does give to management additional insurance—insurance against a calamity which could happen to the company if the products were harmful, or did not do what they were designed to do. We all know of cases where companies have suffered terrific losses and have actually disappeared because the quality of their product was not controlled. It is an insurance, therefore, that companies pay for; but you are responsible for seeing to it that this cost is within bounds. Quality control is a service that will be taken for granted unless the members of the control groups, whether they be purely chemical quality control, or statistical quality control, or any other form of quality control, constantly bring to management's attention the jobs you can do which will make management's job easier and make the quality of the products better.

Quality Control

Is It a Management Service ?

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Mary Parker Follett said that one should not create controversy by assuming that it ought to be there. Now in quality control work we must not make this mistake the other way round. We should never assume that the man we are working with, or the man we are working for, means what we mean by quality control. We should make sure of it. It is wrong to blame him if he misunderstands us. Quality control has been defined (by Dr. Dudding, for whom we British have a profound respect) as 95 percent an attitude of mind. An attitude of mind is not so easily defined as the square root of two. The attitude of mind introduces a variable. That variable is the mainspring of industry—the human element.

Quality control is something new to most people; it is no use saying that it goes back to the pioneer work of Shewhart and Dudding. To industry at large it is a novel concept. The form it takes is made up of a basic philosophy and an individual way of applying it to a situation.

The greatest task ahead of us is to create a better understanding of what quality control is, what it means and what it can do. It can be expressed in general terms but management isn't interested in general terms, management is interested in the application of quality control to its own immediate problems.

We should try to find a better name and use it as a foundation for understanding. We need a name which does not appear to explain it all in two or three words. That is what is wrong with "quality control"—it appears to mean what it says and we know very well that we can't control quality.

It is our job to make quality control easy for management to understand. It is not management's job to find out what we mean. Until we learn to make it easy for management to talk to us and easy to think with us, we run the risk of creating one of three undesirable situations:

1. Management will agree with us, but for the wrong reason.
2. Management will have nothing to do with us, for the wrong reason.
3. Different sections of management may adopt both points of view thus putting quality control between the upper and lower millstone of debate.

The third attitude could be the most damaging. It is my experience that more time can be spent in getting rid of misconceptions than is needed to create understanding in the first place. But better communication of our ideas is *our* job, not management's.

The Approach to Quality Control

It is my belief and my experience that quality control should not be introduced, in the first place, as a check on the supplier's deliveries of raw material and component parts. Management is often led to believe that quality control is a way of cutting inspection costs in the stores. Now we know why and the fault should not be laid at management's door. The acceptance of calcuated and pre-stated risks in inspecting the *other man's* product is based on the use of statistical concepts. This method was first introduced by the Bell Telephone Company, an organization which sub-contracts on a vast scale. Vendor evaluation soon emerged as a by-product of this analytical approach to receiving inspection. The two techniques were introduced far and wide in American industry during the war by the U. S. Government. Ac-

ceptance sampling tables have been published and publicized in the U.S. and in Europe.

But this is not quality control. It is the application of statistical methods to inspection. Because the same statistical principles are used in studying the behaviour of manufacturing processes during, not after, production it is too often thought that quality control and statistical acceptance sampling are one and the same thing. This is a damaging, not just a misleading, state of affairs.

In my experience—and I have had many opportunities for observing—quality control should be introduced first into one's own business. Attention must be given to incoming materials because in any business they are a significant part of the final product. But do not begin with the other fellow: first introduce quality control on your own processes.

Until you have practiced quality control on yourselves you will not learn what quality means or how to judge it. I have more to say about this, later. When you have reduced the overworked word "quality" to realistic, practical, terms your whole attitude to your supplier undergoes a change. You simply cannot afford to buy perfection, nor can you afford to buy rubbish. When you have learned to measure quality, you can find out *how much* quality you need from your supplier. You can judge his performance and, with him, work out what you need and how to measure whether you have achieved it. It is a joint enterprise; the supplier is a partner in your business.

♦ ♦ ♦

The whole subject of quality is clouded and confused by self-righteous thinking. Quality is a much abused word. Quality must always be better or worse than "something"—the first question being "better than *what*." Subjective evaluation is a poor measure of quality for reasons we all know only too well.

I suggest that in any practical analysis quality can only be defined as the gap which separates theoretical perfection and what we hold in our hand at any given moment of time. We must be frank. The gap will always be there because our concept of perfection is itself advanced by technological progress. It is never likely to be reached. It is a very proper target or goal.

The idea of evaluating quality in terms of this gap provides us with the key to "quality control," as we unwisely call it. Measure that gap and you have a concrete measure of quality. It is for this reason that I think of our quality control work as a "measurement service." We are on the job to help people to judge quality by measuring it. We can call this "reducing quality to numbers." Whether it be percent defective or dimensional variability in inches, we are reducing a vague, self-righteous idea to practical terms. I use the word service because that is all we do, we help people to judge for themselves.

Quality measurement service does not explain everything. But I suggest that there is the trouble with the name quality control. It appears to mean what it says. It creates an illusion of consent.

We are inclined to use jargon. We know what we mean but does management? Jargon is a verbal short cut and until we have defined the scope of our work, we should refrain from taking short cuts. They only create confusion in the minds of people who are less interested in the subject than we are because they have other things to think about.

To sum up my argument about how to introduce quality control (or quality measurement service as I call it) make it easy for management and the men on the job to understand what we are trying to do. Don't leave it to them to assume anything. They will probably be confused and that will be our fault. But, above all else, do not lead management to believe that quality control is some new, trick method of inspection.

Management is too often put on the defensive by enthusiastic advocates of quality control. Management need not be told that the quality of its products is important to the business, they have always known that. There exists in every business some method of supervising quality even if it be only a careful watch on the customer's reaction and behaviour. In most businesses there exists some formal method of watching over quality, and whether it be good, bad or indifferent remember one thing—management created it. If the business is successful, it should not be assumed that this system doesn't work.

It is wrong-headed to begin by wanting to destroy something. You will notice that I said wanting—it is our own attitude of mind that we should attend to, first. Management is not going to grasp the shadow and throw away the substance. First let the advocate of quality control create something and let management be the judge—let the manager manage. Make it clear that quality control will stand up to comparison with existing practices—they are usually cherished.

What you want to do is one thing but what management thinks you want to do is usually something quite different. It is not enough to be right; your ideas must appear to be right. Management ought to be cautious—you must be cautious too. The worst thing that can happen to you is to be thrust forward by an overconfident management. However much you know about the theory and practice of quality control, you still have to learn two things:

(1) How to apply it to a situation.

(2) How to stimulate a partnership with the man on the job.

Management will watch the reaction of the production people much more closely than they will watch you. Those people are more important than quality control. They are the business. Quality control is expendable.

You should expect only one thing from management—permission to experiment on one job or one situation. Don't fool yourself by supposing that you are going to prove anything. First convince yourself that you are right. Be patient as well as careful—ask yourself how long did it take you to acquire your faith in quality control? Isn't the other fellow entitled to be given time to agree with you? Exhortation and argument are poor substitutes for conviction.

The Beginning

Enough has been published to enable any reasonable person to experiment on the job. I call this "bringing quality control to life." It is a rewarding exercise. Until I began to experiment with quality control I found it next to impossible to explain to production people what it was all about—I had nothing to show them. But when I suggested that we try our hand at it in order to learn and to test the technique, I was given immediate support and encouragement.

We began of course with a variable study. We knew enough by that time to leave the more difficult attributes application severely alone for the time being. Now this brings me to the core of the ideas I am seeking to place

before you. Quality control (or whatever we choose to call it) will fail, and rightly fail, if we begin by making work for other people. That is no kind of service. It is futile to imagine that other people want their lives to be complicated by someone who is there to serve. Make it easy for management to agree with you. That is more difficult, but more lasting. Management must not be asked to understand us; we must bring our ideas to life in terms which management can accept. A manager who is a manager knows a good thing when he sees it. But show him—don't talk at him. All we need is the opportunity first to practice and then to demonstrate.

♦ ♦ ♦

Quality control is often called "a new management tool." It sounds fine, but it is a wrong-headed concept. Management has enough tools to operate, already. Our job is to ease the load, not to add another tool to the kit. Quality control, I believe, is not a "management tool;" it should be a service to the man on the job. Help him, and you don't need to do anything more for management. We need, today, better management, not more management. And quality control is a form of self management by the man on the job. We should aim to increase his self respect, to increase his interest in what he is doing. The industrial revolution has impaired his sense of partnership in a common enterprise; quality control can replace much that he has lost in the last 100 years.

Having brought quality control to life by a practical exercise, it is much easier to develop other people's understanding and also your own. The object is not to install quality control so much as to learn how to do it and whether it works. Enthusiasm is no substitute for results. I have learned that choosing where to take this first step isn't as easy as it might appear to be. Management, and the man on the job too for that matter, are inclined to think that the place to start is where it is most needed. This is oversimplification. Quality control, like politics, is the art of the possible. The first step is to learn how to do it and to test what you have done. Doing it in real earnest is the third step, not the first or even the second. Choose, for the first step, a job where quality control can be expected to work and produce results.

I suggested that the first step should be the means for gaining practice and confidence. But it does something more than this. It clothes ideas with reality. Now is the time, having made sure that it works, to begin your explanation of what it is all about. You will find it easier now, and so will everyone else.

The explanation phase is a vast subject which I must, in this article, pass over. But I have tried to emphasize that explanation and understanding are more easily attained when you have created a living example in your own business. Quality control is too often thought to be something which only works in somebody else's business —"We are different"—you have heard that many times.

Quality control on the job is essentially an attempt to help an operator to understand more clearly how his machine behaves. He will be surprised to learn two things. You know what I am going to say—

1. That the Process Mean and the Specification Mean are never one and the same thing.
2. That a process does not produce "straight line" results. Its pattern resembles the path of a cyclist.

I make what is a statement of the obvious because I believe that we quality control people are too inclined to spend our time explaining *how* this happens. We talk of chance causes, process averages, deviations, range, within-sample variation, between-sample variation. It is more important first to convince production people that processes behave this way. Explanation should follow demonstration.

The Conclusion

This suggestion brings me to my conclusion. Quality control is a technique developed by mathematicians and statisticians. But quality control will not find its widest use until management is offered a common-sense explanation of what quality control can achieve. How it is to be done interests management much less than what it can do. Quality control is not, in my opinion, a management tool; it is an aid to the man on the job. It saves work for management, it doesn't make work. I have said that management should not be asked to accept quality control blindly, in hope. No good will ever come of "installing" a quality control system. All we need is the opportunity to do two things—first to learn how to apply it to one situation, and then to demonstrate it in action. What the man on the job does with the quality control results is more important than what management thinks of the theory of quality control.

Statistical theory, in my practical experience, is not the explanation of quality control successes. But it sometimes explains its failures. The techniques we use are more subtle than statistics—we bring a process to life. We harness the interest, the experience and the creative ability of the production people. Above all we put a measuring stick in their hands. Management should be shown, by our behaviour, that quality control is what we know it to be: an attitude of mind. Statistics, yes, they are an important element, but when men "take a sample" they do much more than calculate the average and the range—they look carefully at what they have made. This looking is worth quite as much as the calculations. We do not always realize that looking at what you are doing usually means looking for some fault. To look at what you have done is to look, objectively, *at* something. Statistics are a means to an end, not an end in themselves.

You may think that I have grossly understated the contribution of statistical thinking. You may wonder whether I am aware of its significance. I have said nothing which detracts from the significance of statistical disciplines. I have tried to place quality control before you through the eyes of your customer—management. Whenever men invent or discover something new, they support their conviction by producing proofs. In our case management doesn't want proofs of why quality control works; management expects a demonstration that it works and will go on working.

Statistical discipline is essential in our work. Without a clear understanding of the basic concepts on which our technique is built quality control will fail, badly. The need, today, is for simplication of method. The statistician goes on producing elegant ways of using the mathematical approach. The literature is full of them. We see and hear too little about the simplification of the methods of using this expanding knowledge.

I believe that a top-heavy superstructure is being built up on the quality control foundation. Quality control is not research but the dividing line between the two is becoming confused. Engineering and scientific research is the origin of many of the techniques we use. By all means build the end product of quality control into the engineering and research development of tomorrow but never forget that quality control is first and always a service to the man on the job—today.

An Internal Audit

Using Receiving Inspection Techniques

JOHN L. GABLE

Industrial Engineering Div., Collins Radio Co., Cedar Rapids, Ia.

Background

In the Manufacturing Division of Collins Radio Company we maintain a substantial inspection force to check and maintain the quality of our products. We use different techniques in the shop; among them, $\bar{X}$-R and p type control charts; and in Receiving Inspection, acceptance sampling and Lot Plot. All these quality control techniques are used to insure that each production activity attains the quality goals which have been set for it by management.

Would it be worthwhile for us to apply quality control procedures and techniques to some of our office and paper work functions? What is good quality in office work? What is poor quality? Could the judicious use of "statistical control" procedure improve the "quality" of the data generated by our paper work procedures? Could the use of acceptance sampling improve the accuracy and/or reduce the cost of our auditing and systems monitoring activities?

This last question we shall try to answer by explaining the procedure and concepts associated with acceptance sampling as used in the Receiving Inspection Department which were employed by the Internal Audit Department in their recent vendor tooling audit.

In Receiving Inspection, we realize that sufficient checking to insure 100 percent good parts would be prohibitively costly. We therefore determine a percentage defective which, from an economic viewpoint, we can "live with" on our assembly lines. This percentage may vary all the way from one percent for expensive electronic tubes or switch assemblies which, if defective and placed in a unit on the assembly line, will require expensive tear-down for replacement, up to six percent defective for bolts, nuts, screws, and other hardware, which is easily replaced. This quality level which we wish to accept a majority of the time is called the *Acceptable Quality Level,* (AQL).

The *Objectional Quality Level** (OQL) is the level of product quality which we would seldom wish to accept. We would seldom want a lot of complex switch assemblies which were five or six percent defective issued to our assembly line; with hardware we would usually want to exclude from issue lots 15 or 20 percent defective.

What do we mean by "accept a majority of the time" and what do we mean by "seldom accept"? Don't we want to accept "good" lots all the time and reject "bad" lots all the time?

This we could do, theoretically, by checking all lots 100 percent, but the cost would be prohibitive. We resolve this conflict by choosing an economical procedure (statistical sampling) that correctly distinguishes between the two kinds of lots most of the time.

*Also known as Lot Tolerance Percent Defective (LTDP).

TABLE 1—Accepting or Rejecting Lots

True Condition of Lot	What We Say About Lot	
	Accept the Lot	Reject the Lot
Material is "Good" (AQL quality or better)	Our decision is correct	Type I Error (Calling good material bad) Risk α
Material is "Bad" (OQL quality or worse)	Type II Error (Calling bad material good) Risk β	Our decision is correct

Because we are basing our decision on a sample, we can make wrong decisions. (Consider Table I.)

The terms "accept a majority of the time" and "seldom accept" can now be given a precise mathematical meaning in terms of the two types of errors illustrated in Table I. The "Risk of making a wrong decision of Type I" usually associated with good quality is $\alpha = 5$ percent. We make the statement that we wish to accept submitted material which is as good as the AQL or better 95 percent of the time or more. The acceptance level usually associated with the objectionable quality level is 10 percent or, stated another way, the "Risk of making a wrong decision of Type II" is $\beta = 10$ percent. Thus, we make the statement that we wish to accept 10 percent or less of the time submitted material which is as bad as or worse than the objectionable quality level.

From an engineering judgment which determines the values for the AQL, the OQL, and "risk of making a wrong decision" to be associated with each, the statistician can derive what is known as a sampling plan. Such a plan for the Receiving Inspection Department might consist of instructions:

> "From a lot of 5000 items, take a sample of 125 items. If three or less defectives are found in the sample, accept the lot of material. If four or more defectives are found in the sample, reject the lot of material."

TABLE II—Accepting or Rejecting Records

True Condition of Tool Records	What We Say About Tool Records	
	Tool Records are Accurate	Tool Records Need Corrective Action
Tool Records are accurate (AQL quality or better)	Our decision is correct	Risk of Type I Error, α, to be about 1%
Tool Records are inaccurate (OQL quality or worse)	Risk of Type II Error, β, to be about 10%	Our decision is correct

Notice that this type of plan is really a decision making function. The inspector does not have to make a statement about percentage defective nor any judgment as to what is good quality or what is bad quality. The inspector in Receiving Inspection simply takes a sample of 125 pieces *at random*, inspects them, and then compares the number of bad pieces with his criterion, i.e., accept if three or less, reject if four or more defectives are found.

Before going into an example of the application of acceptance sampling to paper work procedures, let us consider the classification of errors possible in paper work. In the Receiving Inspection area it is usual to talk in terms of either defects or of defectives. A defect is any deviation from the dimensions established on the blue prints or specifications. A defective is a piece which contains one or more defects. It is possible to express quality in terms of either number defective or number of defects. Suppose that we consider a piece of paper or form as analogous to the piece part submitted to Receiving Inspection. The number of defects or the number of defectives can be our criterion for quality determination. The plans used in this article are based on number of defectives in the sample.

Application

Let us now consider the problem of auditing tool loan records. We know that occasionally errors are made in tool records, shipment records, postings, etc. Collins Radio Company has approximately 300 different vendors who have Collins owned tools in their shops. Some of these tools are issued on tool loan orders; some are issued on purchase orders. We wish to know if our records accurately reflect the status of the tools loaned to our vendors.

If our records system has been accurate in the past, we should probably continue with it. However, if our records are very inaccurate, it would probably pay us, at this time, to take corrective action. This might consist of performing a complete audit of these records, installing cyclic audit or internal check procedures, or perhaps retaining certain personnel.

We are therefore faced with the problem of explicitly stating three things:

1. What will constitute a defect in our tool record system?
2. What are "good" or accurate records, i.e., records that tell us the story we wish to know?
3. What constitutes "poor" or inaccurate records, i.e., how bad should things be before we institute corrective action?

The Internal Audit Department defined a defect in the tool records as any difference between a vendor's indicated tool status and the information on the tool card.

The Internal Audit Department also decided that if these records are accurate within four percent (i.e., only four percent of the tools that are supposedly on loan to vendors have been lost, misplaced, missent, or their records had been the subject of a clerical error) they would consider this as a satisfactory level for the record system. In other words, they have set the AQL for this audit as four percent. However, the Internal Audit Department had indicated that if our records are so poor that ten percent of our tools are improperly accounted for, then the decision should be to take some type of corrective action. Our OQL is therefore ten percent defective.

The auditors also indicated that risks of wrong decisions of the magnitude indicated in Table II would be satisfactory.

We have now defined all the parameters necessary for us to design the audit of tool records. We have stated that if the records are four percent defective or less, we wish to accept them as correct and do nothing 99 percent of the time. We have also stated that if the records are ten percent defective or worse we only wish to accept these records as being good about ten percent of the time. Note that both statements are in terms of accepting the hypothesis that the records are accurate. The assumption is that if this hypothesis is rejected, management will institute the appropriate type of corrective action.

At this point the question comes up, "How do I proceed from these statements of good and bad quality and associated risks to a plan for action." Tables have been developed which show, for various lot sizes, the proper sample size and acceptance numbers to be used for various AQL's. MIL-STD-105A is the set of such tables which is used by the Collins Radio Company Receiving Inspection Department. It was also used for the tool loan record study.

The statistical determination of sampling plans is based on the assumption that the sample data come from a "random sample." The next question that arises is, therefore, how shall we draw our sample? This question was answered by using a "table of random numbers." This statistical tool is an arrangement of digits whose sequence has been de-

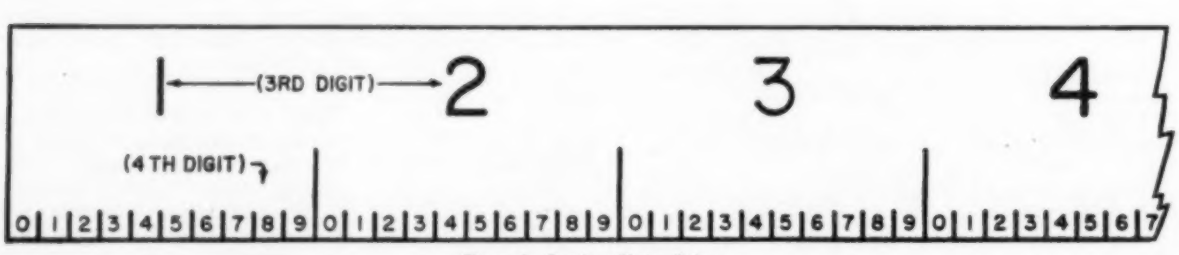

Figure 1—Random Choice Ruler

termined by a carefully randomized process.

The following procedure was used to translate random numbers into the choice of a tool card. The assumption was made that the master file of tool numbers maintained in the Tool Design Department was correct. This file contains approximately 50,000 tool numbers. The tool number cards are maintained in eighteen file drawers, approximately 22½ inches of depth in each drawer. The code which was developed to translate a four digit random number into a card location is shown in Table III.

A "ruler" was developed to speed the choice of the card when the drawer was pulled. This ruler was laid on top of the cards; the choice of individual cards within the ¼-inch increment was left to the person drawing the tool number. (See Fig. 1.).

Initially, consideration was given to basing the sampling procedure on the tool numbers on each card. One problem with this was that tool numbers, which are part of the Collins part number system, are in nonconsecutive blocks. The other was the time required to find and record the information from a specific card. It was felt that the procedure described above, though perhaps not theoretically "pure" because it left the choice within ¼ inch increments to the sampler, provided a sample as nearly random as the economics of the situation would warrant.

Before we could determine the sampling plan for the audit, it was necessary to estimate the number of tools which were on loan to vendors. We checked the first 140 tool record cards pulled for the sample; they showed 27 tools on loan to our vendors. Using this 19 percent, we estimated our tool loan population at 9,595. Referring to Tables III and IV-A of MIL-STD-105A, our sample size should be 300 tools that are on loan. For an AQL of four percent our acceptance number is 20, our rejection number is 21.

The procedure for the entire audit was:

1. A random sample of tool numbers was drawn until a sample of 300 tools which are at vendors had been listed.

2. Letters were sent to the vendors who, our records indicated, were supposed to have the tools in the sample. They were asked to check for the physical presence of each tool listed in their letter. A copy of the letter is shown in Fig. 2.

TABLE III—Random Card Choice Code

First two digits	Drawer No.	Third digit*	Position from front of drawer	Fourth digit*	Position from front of third-digit group
01-05	1	0	next sample	0	0 - ¼"
06-10	2	1	0 - 2½"	1	¼ - ½"
11-15	3	2	2½- 5 "	2	½ - ¾"
.	.	3	5 - 7½"	3	¾ - 1"
.	.	.	.	.	.
.	.	.	.	.	.
86-90	18	.	.	.	.
91-99	next sample	9	20 -22½"	9	2¼-2½"

*Figure 1 shows how the third- and fourth-digit codes were combined on a ruler for easy use.

3. If the replies to these letters indicated 20 or less discrepancies existed in our sample of 300 tool records, we were to accept our present records as correct. If, however, 21 or more discrepancies were noted, corrective actions were to be considered.

As a result of this survey, 293 replies about specific tools were received. Six vendors did not reply to the letters. The number of discrepancies uncovered by the study exceeded the rejection number of 21. These discrepancies fell into four categories:

1. Collins records incorrect, records adjusted.
2. Lost by vendor, Collins not notified.
3. Expendable type tooling.
4. Unable to determine exact responsibility.

(Continued on page 22)

COLLINS RADIO COMPANY
CEDAR RAPIDS, IOWA, U.S.A.

Gentlemen:

In connection with our internal audit of tooling, we desire to confirm some of the Collins' tooling which our records show to be held by you as listed in the attached schedule. The tools listed in this schedule were selected at random from our files. Although you may have other Collins' tooling in your possession, we are requesting that you confirm only those listed in the schedule.

Kindly indicate in the space provided below whether or not your records agree with the attached schedule. Please return one signed copy of this letter and attached schedule to:

Collins Radio Company
Internal Audit Department
855 - 35th Street, N. E.
Cedar Rapids, Iowa

Very truly yours,

R. M. Matthews
Internal Auditor

To Internal Audit Department:

The data in the attached schedule agrees with our records with the exceptions noted thereon (if any).

Signed _____

Company _____

Figure 2—Letter Sent to Vendors

ASQC CONVENTIONS

12th Annual Convention • May 26, 27, 28 • 1958 • Boston, Mass.

ASQC GENERAL CONVENTION COMMITTEE

Chairman
Wade B. Weaver
Republic Steel Corp.
Cleveland, Ohio

Publicity
Frank Caplan, Jr.
Westinghouse Electric Corp.
Chesswick, Pa.

Exhibits
Charles R. Kendel
Lamson & Sessions Co.
Cleveland, Ohio

Program
John G. Rutherford
Lear, Inc.
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Transactions
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American Radiator and Standard Sanitary Corp.
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General Electric Co.
West Lynn, Mass.

Arrangements:
Martin W. Rogers
The National Company
Malden, Mass.

Exhibits:
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Keystone Manufacturing Co.
Dorchester, Mass.

Reception:
Harold J. Davis
Raytheon Manufacturing Corp.
Newton, Mass.

Registration:
Dorothea R. Looney
The Polaroid Co.
Cambridge, Mass.

Book Booth:
Bernard P. Goldsmith
Raytheon Manufacturing Corp.
Newton, Mass.

Secretary:
Frances B. Hermann
Arthur D. Little Co.
Cambridge, Mass.

Advisory:
Leonard A. Seder
Quality Control Consultant
Malden, Mass.

January 10, 1958

To Fellow Members and Friends of A.S.Q.C.

Quality will keynote the 1958 Convention of the American Society for Quality Control.

Progress appears to occur in steps rather than on a straight-line basis. On May 26, 27, 28, 1958, you should plan to be among those present to witness a large upward step in the quality of A.S.Q.C. Conventions. To achieve this step, the Boston Host Group has worked hard for two years, designing and organizing the building of a quality convention.

As with any product, the first objective was to design a quality convention. The best from previous conventions has been combined with new ideas in designing the 12th Annual Convention of the A.S.Q.C.

For example:

1. The Statler and Sheraton Plaza, two of Boston's finest hotels, will house the convention in luxurious air-conditioned accommodations.
2. The design of the brochure has been changed to provide a clearer picture of convention activities.
3. Brief synopses of forthcoming talks will be posted on special bulletin boards to assist you in choosing the presentations of greatest interest.
4. Sixty-four papers have been painstakingly developed to include the best of the speakers and subjects in the Quality Control field.
5. The program format has been modified to allow more time to view what promises to be the best A.S.Q.C. Convention Exposition ever held.

The second objective of your 1958 Convention Hosts is to insure the quality of conformance to design. The group has organized both manpower and brainpower to guarantee conformance to specifications.

When you attend the Convention, you will see the success of the planning organization--not only in the technical program, but in the fields of accommodations, plant tours, ladies' program, luncheons, and exhibits.

Remember then—we have a date,
May Twenty-Six through Twenty-Eight
In A.D., 1958.
Plan to attend—and don't be late!

Warren J. Grosjean

Warren J. Grosjean, Chairman
Boston Convention Committee

ASQC Convention Exposition Chart

12TH ANNUAL CONVENTION AND EXPOSITION
HOTEL STATLER • BOSTON, MASSACHUSETTS
MAY 26 - 28, 1958

HIGHLIGHTS

NATION'S INDUSTRIAL EYES WILL BE FOCUSED ON BOSTON . . .

Without a doubt, Quality Control is the nation's fastest growing profession. From an initial membership, just one year after its founding in 1946, of under a thousand, ASQC has soared to 10,500 in 1957. It is now taking an important and vital place in American industry. And this role will be highlighted at the coming 12th Annual Convention in Boston, May 26-28. You'll want to attend this conference, so as to keep abreast, or a step ahead, of fast-moving future developments in modern industrial operations.

FOREMOST QUALITY CONTROL EXPERTS TO GIVE PAPERS . . .

H. Cohen of The Glenn L. Martin Company will report on "The Progress of Project Vanguard." His paper will review the scope of the Vanguard program, its importance to the scientific world and what useful data we hope to obtain from it.

In another field, that of Administrative Applications, Grant I. Butterbaugh, Professor of Statistics, University of Washington in Seattle, hits hard at present day educational systems in his paper "Applications of Statistical Methods in Business Administration." His subject is current and challenging. He calls a spade a spade when he says, "Parents today are rearing soft children and should insist that teachers work their children harder and longer. We need a policy of a full laboratory and a full library throughout the week instead of a full stadium every Saturday."

Hard words, yes, but he has a strong point.

More than 60 technical papers by outstanding leaders from the United States and abroad, covering over a dozen fields of interest such as automotive, aircraft, education, chemical, manufacturing and assembly, operations research, textiles, and etc., are to be presented, which makes it a must to attend this convention if you want to know the direction industry of tomorrow will move.

EXHIBITORS' LIST FOR CONVENTION GROWING . . .

A large number of informative exhibits are being arranged by the Convention Committee again this year to show the new tools and latest methods employed by the Quality Control industry. They promise to be a great help and you'll want to see first hand these new services and devices. If you have a product, system or service, make sure your company will have a display. The list this month was joined by:

The B. C. Ames Company, Waltham, Mass.
The American Cystoscope Makers Company, New York, N. Y.
The Comtor Company, Waltham, Mass.
The Greist Manufacturing Company, New Haven, Conn.
Wilson Mechanical Division, American Chain and Cable Co., Bridgeport, Conn.
The Continental Can Company, New York, N. Y.
Gillette Safety Razor Company, Boston, Mass.

DIVISION MEETINGS, PLANT TOURS, SOCIAL FUNCTIONS . . .

A full program, not only to give you an insight as to how others do it, but covering the fun side as well, is being arranged by the Convention Committee. More complete details on these activities will be announced soon. But New England has long been known for its Old Fashioned Hospitality and the Boston Committee isn't going to let you forget it.

TO ASQC MEMBERS:

As a user of Quality Control, your company should exhibit to promote the interchange of technical information on the methods of Quality Control.

Please pass this page on to your sales manager, exhibit manager, or advertising manager so that he can make plans for your exhibit.

Be sure all of your suppliers exhibit!

For information on exhibit space or about the Exposition, write to:

American Society for Quality Control
c/o Andrews, Bartlett & Associates, Inc.
1849 West 24th Street
Cleveland 13, Ohio
TOwer 1-6045

Cut Costs with SHEFFIELD Adjustable AIR GAGE TOOLING

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- **Aircraft manufacturers, subcontractors and job shops having limited production.**
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- **A short run of special parts for which no gages have been provided.**
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Don't let any of these situations cause costly scrap, delays or embarrassing confusion in inspection, in the shop or in the toolroom. A small investment in the tooling here illustrated is your best insurance against unpredictable production losses.

Write Div. 22 for descriptive engineering data. ***THE SHEFFIELD CORPORATION, Dayton 1, Ohio, U.S.A.***

All items shown here are stocked for immediate delivery—no waiting.

Economical, Adjustable Balljet Spindle Kit

In 5 minutes you can assemble, for precision gaging, a spindle for ANY SIZE hole from 1" to 3" in diameter.

Consider economy for a moment. If the holes you may encounter vary in increments of .001", this Kit provides the equivalent of 2000 Spindles at a unit cost of less than a dollar. If those increments are .0001" you have available 20,000 Spindles at about a dime each. That is real economy.

No auxiliary equipment needed except conventional gage blocks—NOT EVEN ONE MASTER SETTING RING.

Adjustable Balljet Spindle Kit

Balljet Spindle assembled

Balljet Spindle in use

Calibrating Fixture

Adjustable Airebore Gage

Adjustable Airebore Gage

Airebore Gage assembled

Airebore Gage in use

The Airebore Gage can be set precisely to measure any diameter hole from 3″ to 12″. And like the Adjustable Balljet Spindle, it is set up with a calibrator and gage blocks. No master setting rings are needed.

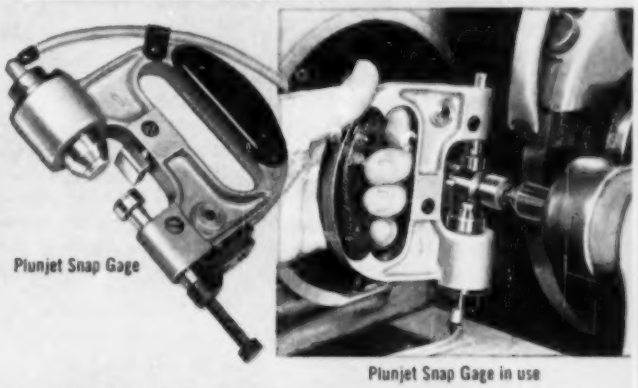
The Airebore Gage is self-centering—needs only to be rocked in place for precision action. It is light in weight with all contact surfaces of tungsten carbide—nothing to wear out.

Three-Point Adjustable Spindles

Three Point Adjustable Spindles

The Three-Point Adjustable Spindles, four of them, cover respectively the ranges, ⅜″ to 9/16″, 9/16″ to 1″, ⅞″ to 1½″ and 1½″ to 3″. They can be set up with gage blocks.

Plunjet Indicator Snap Gage



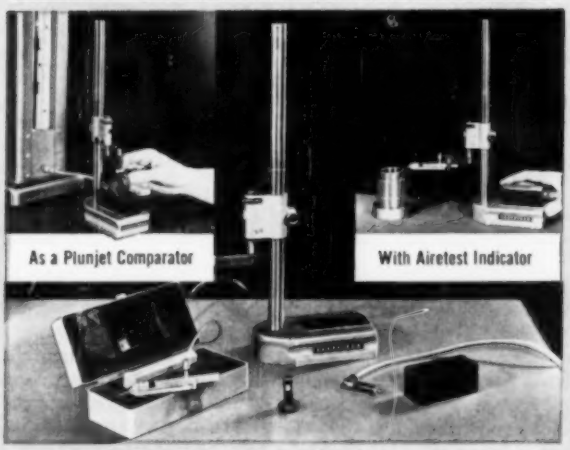
Plunjet Snap Gage

Plunjet Snap Gage in use

The Plunjet Gaging Cartridge may be substituted for the Dial Indicator to assure consistent, repetitive readings, especially when tolerances are .001″ or less.

Twelve Plunjet Snap Gage models cover the gaging range of 0″ to 12″. Larger sizes are available on special order.

Airetest and Plunjet Stand

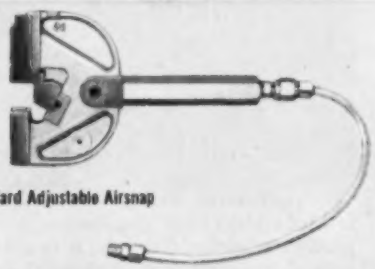


As a Plunjet Comparator

With Airetest Indicator

A new, highly versatile stand accommodates a dial indicator or an Airetest Indicator—also converts to a comparator by using a Plunjet and anvil as illustrated.

Standard Adjustable Airsnaps



Standard Adjustable Airsnap

The Standard Adjustable Airsnap in 17 models covers the range .2500″ to 5.500″. Up to 3.000″ the adjustable anvil has a maximum adjustment of ¼″. Above that the maximum is ½″.

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(Continued from page 17)

The largest single category consisted of records of expendable tooling retained by the vendors and assigned a tool number. Prior to 1951 a definition of expendable tooling had not been firmly established; as a result many items were assigned tool numbers which would not today receive one. A screening process has been established in the Tool Department to eliminate unnecessary numbering and accountability for expendable tools.

Figure 3 shows the "operating characteristic curve" of the sampling plan which was used. From it one can tell what the probability of calling the tool records "good" (i.e., not requiring corrective action) if the true quality level were, for example, six or eight percent.

It should be noted that this entire procedure has been the basis for making a decision and that no statement has been made about true process level.

The technique used to check tool loans can be applied to several other places in our company. Whenever the question arises about a paper-work process, "Is it good or is it bad?"; the second logical question is, "What do you mean by 'good' and what do you mean by 'bad'"? This article has shown how to define what is good paper-work or a good administrative procedure and what is bad, and how to establish a sampling procedure which will lead to a conclusion.

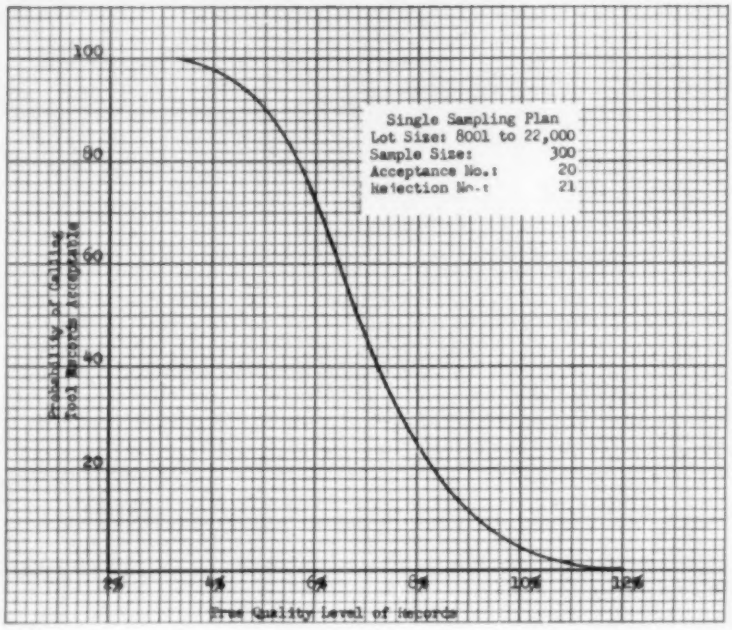


Figure 3—Operating Characteristic Curve of Tool Record Sampling Plan

An important aspect of this procedure is the fact that, while we are defining good and bad quality before taking a sample, we are also forced (1) to recognize the two types of decision error which can be made using sampling and (2) to establish the "Risk of making a wrong decision" to be associated with each error.

What's New?

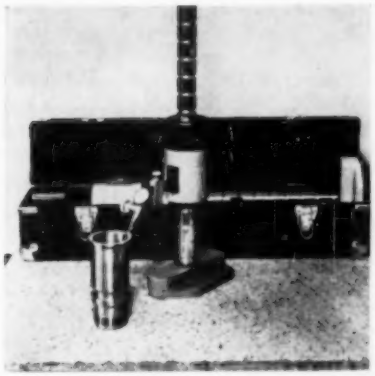
ROY A. WYLIE, *Editor*

When inquiring about "What New?" items, please mention INDUSTRIAL QUALITY CONTROL

The United States Testing Company, Inc., 1415 Park Avenue, Hoboken, N. J. has developed a new Impact Tester which employs a revolutionary technique to obtain the measurements of impact strength for plastics, paper, rubber, boxboard, and similar materials. Impact strength is found on this instrument by measuring the energy lost by its swinging pendulum when it breaks through a sample. Energy of the pendulum on an uninterrupted swing is compared to its energy after breaking the sample. The instrument differs from other impact testers in its measurement of pendulum swing distance, a fundamental quantity in the energy determination. To achieve greater accuracy, distance is not measured directly on the Pendulum Impact Tester but is calculated from the pendulum swing time, measured to within 0.001 second on the instrument's electric timer. In practice, this value is converted directly to impact strength on conversion tables supplied with the tester. The Pendulum Impact Tester provides a fast, reliable method for product inspection and "in process" testing. The complete test procedure takes only a few minutes and no special sample preparation is required. Readings made on the Tester give an absolute impact strength value which is highly reproducible, even among a number of operators. To simulate different kinds of impact, the tester is equipped with a set of interchangeable striking heads. In addition, detachable pendulum weights provide for testing in a wide range of impact strengths. Reproducible impact strength values have been obtained on the instrument for materials ranging from cellophane to heavy boxboard.

* * *

Pacific Gage, Inc., A Division of Darco Industries, Inc., 2151 E. Rosecrans Ave., El Segundo, Calif., has introduced the Height Master, a portable, completely self-contained instrument specifically designed for use in precision layout work, inspection, checking jigs and fixtures or wherever fast and highly-accurate height measurement is a necessity. The unit eliminates the need for gage blocks, transfer measuring equipment or reference gages of any kind. The indicator is zeroed on the surface plate



and the head is moved to the desired inch. By turning the thimble, the arm is moved to the hundredth reading on the vertical scale and the thousandth reading on the micrometer scale. It is unnecessary to pick up the Height Master to read it and no magnifying or special reading glass or special lighting is required. The Height Master lends itself to scribing a part as it slides along smoothly on any plane surface, including machine work tables. The carbide inserts in the base minimize wear. Extension arm on the Height Master is adjustable vertically on the column from 2 to 17 or 24 inches depending on the model used. Horizontal adjustments are variable over a range of 1½ inches and can be further increased with a longer measuring unit or extension arm. Accuracy is guaranteed within 0.001 from 2 to 24 inches, on standard models and within 0.0005 from 2 to 24 inches on special models recommended for checking fixtures, drill jigs and for precision layout or inspection work.

★ ★ ★

The George L. Day Co., Inc., 1227-1231 Niagara Street, Buffalo 13, N.Y. announces the production of new Full Automatic and Semi-Automatic Speeders for high speed testing of cut-off saws, cup and plain grinding wheels. The Day Speeder makes it possible to do 100 percent individual speed test inspection. The Standard Model handles wheels up to 4 inches thick and 20 inches in diameter, and other models for larger sized wheels are available. Preset testing speed up to 15,000 rpm with smooth rapid acceleration and deceleration is possible. In operation, pushing of two hand starting buttons begins the cycle in which the wheel is elevated, the safety cover closes, the wheel is clamped to the turn table, the wheel accelerates to the preset speed and decelerates to stop, the wheel lowers to the unloading position. The entire unit is self-contained and the

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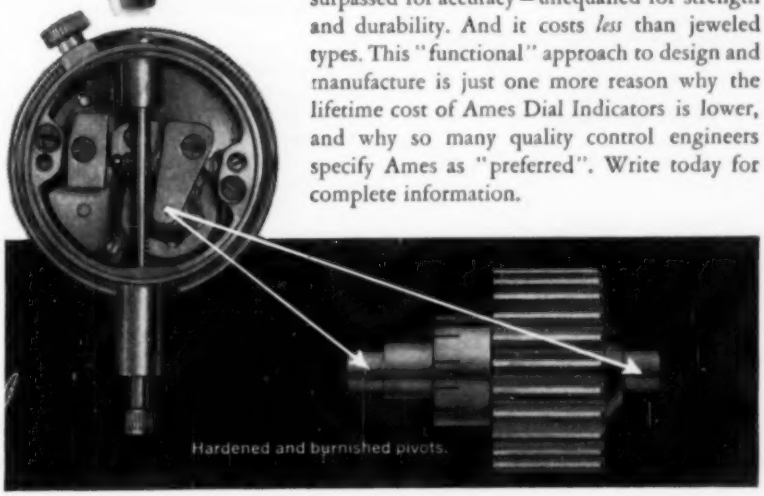
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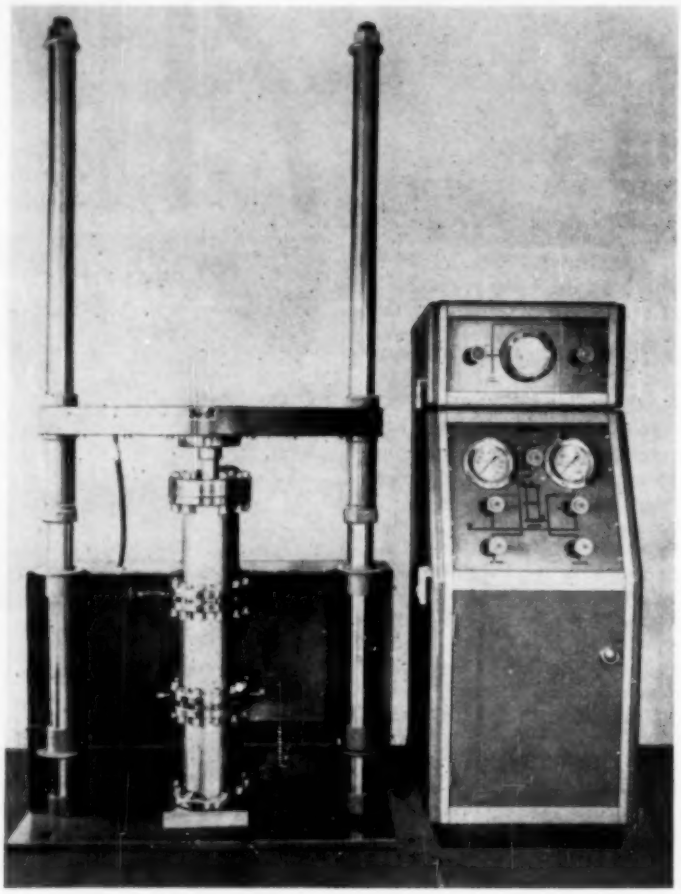
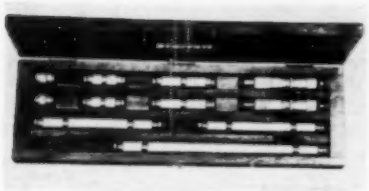


Four times greater thrust force is now possible in a new model of the Hyge Shock Tester, available from the **Rochester Division of Consolidated Electrodynamics Corp.**, 1775 Mt. Read Blvd., Rochester 3, N.Y. This instrument accurately simulates shock experienced by equipment in actual use. Applications include the shock-testing of components of aircraft, turbines, missiles, rockets, and other industrial equipment. The Model HY-6000 Shock Tester produces extremely high loads instantaneously, with thrusts up to 40,000 pounds. Shock pulses are accurately controllable for both waveform and acceleration and deceleration level, whether the waveform is square, triangular, cosine, or sine pulse. Repeatability is exact, and the acceleration-time waveforms are free from high frequency transients. The HY-6000 is essentially a six-inch diameter cylinder containing a piston which is subjected to differential pressures on its two faces. It has only two moving parts—the piston and a floating seal—and requires no complicated controls or elements.

The Hyge Shock Tester is built of modular components and is available in a variety of configurations to meet any application. It is also available in kit form and can be easily adapted to solving a wide range of problems.

★ ★ ★

Sets of highly accurate end measuring rods for use with jig borers and measuring instruments where table settings or spacing must be held to a high degree of precision are now available thru distributors of Starrett precision measuring tools. The No. 244 series rods are available in 1, 2, 3, 4, 5, 6, 7, 8, 10, 12 and 15 inch sizes (also in Metric) and may be purchased in standard sets or in any combination of sizes to suit specific requirements. Also available are two micrometer heads, each of 4 to 5 inch range, graduated to read in ten-thousandths of an inch (or hundredths of a mm). Complete specifications covering the range of sets



available are given in a catalog published by the **L. S. Starrett Co.**, Athol, Mass.

★ ★ ★

The 10,000 pound B-L-H Mark G Servomatic tester—the first testing machine in which the center of test always remains at the same point regardless of length of specimen or amount of extension—has been developed and built by the Electronics and Instrumentation Division of **Baldwin-Lima-Hamilton Corp.**, Waltham, Mass. The center of test is situated 56½ inches above the floor for easy observation and application of auxiliary test equipment. The Mark G machine achieves a motionless center of test by making two crossheads pull against each other or compress toward each other. In all previous machines, either the crossheads or the table were fixed. The crossheads are actuated by two ball and screw mechanisms. In addition to providing the means for moving the two crossheads simultaneously, the two ball and screw mechanisms have inherent design advantages. The point of contact between the screw and its opposing thread is a ball bearing. Rather than screw and thread turning against each other directly, with consequent high friction, the bearing turns between them and friction is substantially reduced. This arrangement leads to a more sensitive response of the machine and to lower power requirements. Four SR-4 load columns in the upper crosshead do the measuring. The loads measured are the forces between the crosshead and the actuating nut assembly, rather than

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forces transmitted to the base of the machine. In addition to testing samples in tension or compression, the machine is equipped to apply alternating loads. Automatic strain or load cycling is possible at frequencies of from 0.06 to 60 cycles per minute. The console for the Mark G also incorporates features not usually found in equipment of this sort. An automatic X-Y plotter is built in. This will plot crosshead motion or strain vs load using either microformer extensometers, SR-4 gages, or SR-4 extensometer vs load. An auxiliary plotter, also mounted in the console, will plot load vs time and strain vs time simultaneously with the X-Y plotter. The design will also be available in the 60,000 pound size and can be built in a range of sizes up to 300,000 pound capacity.

★ ★ ★

To facilitate accurate height gage readings on parts with higher than normal check points, the **Herman Stone Co.**, 1860 N. Gettysburg Ave., Dayton, Ohio, has developed a series of granite riser blocks. Fingertip control of the 300 pound blocks is made possible by an "air lift" feature. These riser blocks provide an accurate granite surface parallel to the working surface plate and at an elevation sufficient to allow use of standard height gages. The air lift feature allows the operator to guide the heavy block into position with the touch of a finger. As the block actually floats on a cushion of air, there is no wear on the surface plate or the block itself while it is being moved from one position to another. Air, at about 40 psi, is piped into a hole in the back of the block and led to a series of grooves on the bottom surface. These grooves are cut to within two inches of the edges so that, if the block is moved too close to the side of the surface plate, the air escapes. This safety feature prevents the block from "floating off" the surface plate. When the block has been positioned, the operator shuts off the air supply and the block becomes stationary. Typical Herman granite riser blocks are 24 inches high and 14 inches across the top. They are also available in square or cylindrical shapes and in various sizes. Top and bottom surfaces are flat to a maximum reading of 0.000050 inches and parallel within 0.000075 inches.

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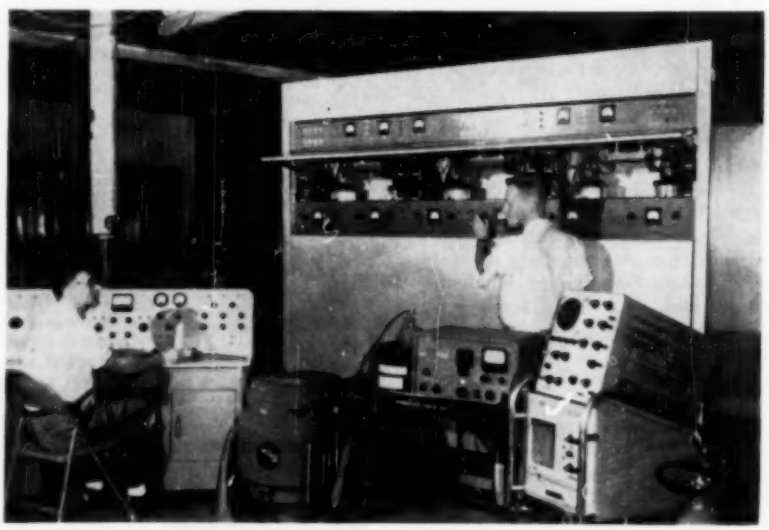
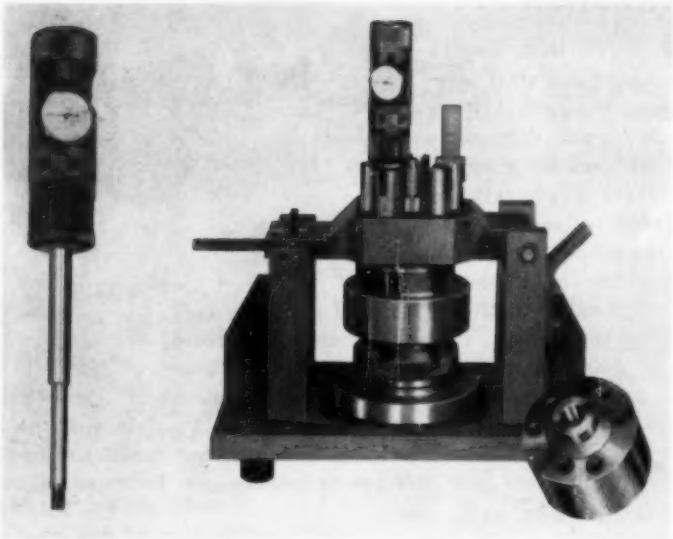


A new series of three high-rated power amplifiers designed and built by **MB Manufacturing Co.**, A Division of Textron, Inc., New Haven, Conn., will extend the frequency and force ranges of vibration test systems for sinusoidal and random motion excitation in electronics, aviation and missiles development. The new 7.5, 15 and 22.5-KVA power amplifiers are added to the present line of specialized vibration test amplifiers which have been produced by MB Manufacturing since 1945. The MB Models T444 (7.5-KVA), T666 (15-KVA) and T888 (22.5-KVA) have a plate dissipation of 18-KW, 32-KW and 54-KW respectively, the latter being larger than any AM broadcast transmitter in the United States. These amplifiers have the following performance characteristics of major interest to environmental test engineers:

1. Rated power output is maintained over wide frequency range into any power factor load from 0.2 lead to 0.2 lag. These amplifiers can then be used for wide-sweep sinusoidal testing and random-motion studies which must be done without power factor correction or intermittent impedance mathing.
2. Flat frequency response is maintained over a wide range, ± 0.5 db from 5 to 5,000 cps.
3. A single basic power cabinet, 84" high by 98½" wide by 69" deep, houses each of the three amplifiers. Because the T666 and T888 Models comprise two and three T444 power output units respectively, a 7.5-KVA T444 vibration-test power supply can be easily expanded at a later date to 15-KVA (T666) and then 22.5-KVA (T888) in the original cabinet on location.

★ ★ ★

Mayes Tool Co., 26514 W. Seven Mile Road, Detroit 19, Mich. have made available the "CON-CHEK," a gage that permits checking hole location and concentricity, without turning either one's hand, or the gage han-



dle. The "CON-CHEK" is inserted into a master fixture, with the indicator face-up for convenient reading. The inspector may then rotate the knurled thumbknob just above the handle of the gage, which rotates the extension spindle. The gage handle and the indicator do not turn—and the indicator remains face-up for immediate checking. The outer shaft of the pilot also remains stationary. This reduces wear on the precision ground and lapped chrome plated spindle. The "CON-CHEK" is available in a full range of models made up of stock components to meet most hole locations and concentricity checking requirements. The smallest model has a measuring capacity of 0.200 inches diameter minimum, while the capacity of the largest standard model is 1.750 inches diameter. All standard models have a range of 0.060 inches but other models with greater capacity and range are available on special order. All are equipped with AGD Group 2 Indicators.

★ ★ ★

New Literature

A brochure describing the Model 154-C single-stage vapor fractometers, new gas chromatography instruments, has just been published by the Perkin-Elmer Corp., Norwalk, Conn.

The Electronics Division of Post Machinery Co., Beverly, Mass., has issued new catalog sheets describing some electronic equipment available for Quality Control work. Items covered are the Model ER-1, Edge Register Detector (for accurate control of materials manufactured in continuous form) Model F-2, Direct Impulse Counter (for counting up to 10 units per second) Model PW-5. A five selection preset counter(which counts up to 5,000 units per second with selective warning system actuator on any predetermined count.) Model LF-1A. Lineal Footage Counter and readout (for accurately counting web length etc. and transferring reading at any time.) Model P3-RM, Electronic Counter for cartoning, etc., with rate per hour totalizer on face.

Fischer & Porter Co., 99 Jacksonville Road, Hatboro, Pa., has just published a catalog on the Press-I-Cell, an instrument for the precise measurement of absolute, gage or differential fluid pressures. The catalog describes the Press-I-Cell as measuring gases or liquids over pressure ranges from 0-4 psi to 0-1000 psi with a degree of accuracy as high as 1 part in 2000. Readability of the scale is of the order of 1 part in 8000.

A new desk sized chart containing conversion data for Rockwell tests and other hardness scales is available from the Torsion Balance Company, Clifton, N. J. In addition to hardness conversion, this chart also has tables for cylindrical corrections.

The Exact Weight Scale Co., Columbus, Ohio offers a new eight page brochure on the Shadograph Scales designed for use in the instrumentation and automation of industry. It contains numerous illustrations, detailed specifications and important features of 34 different models, ranging in capacities from 2000 mg up to 100 pounds.

QUALITY CONTROL METHODS AND MANAGEMENT

The result of the symposium held in September 1957 at Drexel Institute of Technology and sponsored by the Philadelphia section is nine papers which comprise the "symposium transactions."

These papers present some of the quality control methods that are tools for management and also present some management views on quality control. Here are the subjects covered.

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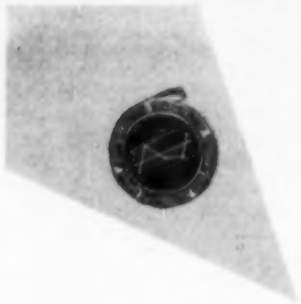

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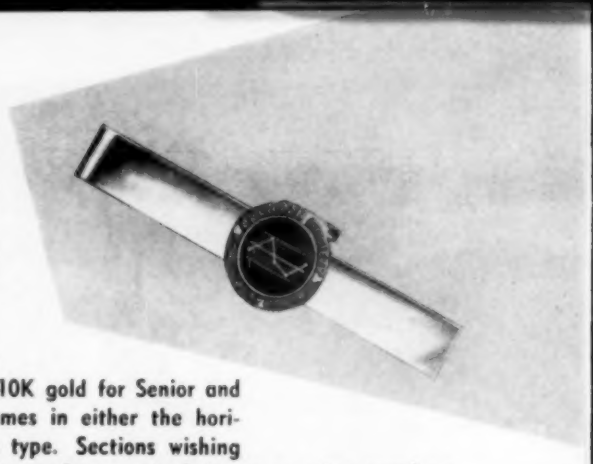

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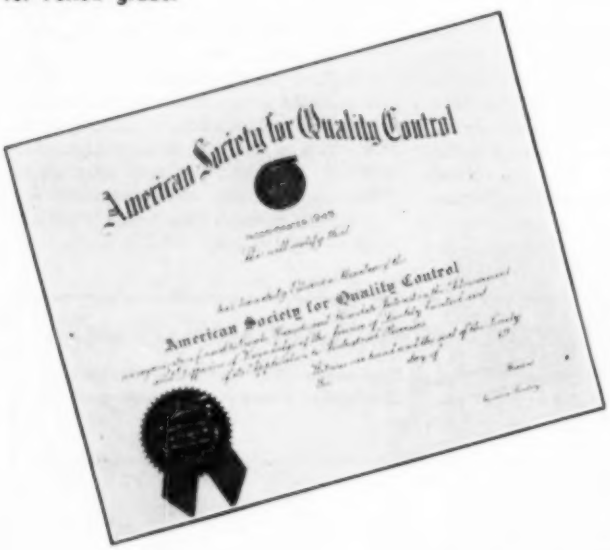
The bar is silver for Member grade and 10K gold for Senior and Fellow grade. It comes in either the horizontal bar or chain type. Sections wishing to use these for awards to past chairmen or other members will find them especially suitable. The surface of the bar, which is shown here slightly larger than actual size, is plain so that your message or citation can be engraved on it.



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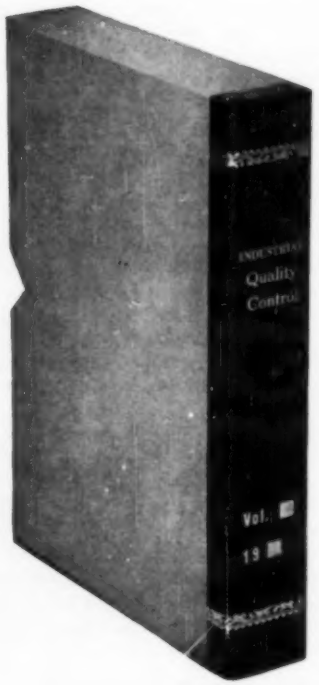

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Brookfield Engineering Laboratories, Inc., Stoughton 112, Mass. has announced the availability of a new application data sheet on the Brookfield Viscometran. The new four page, two-color brochure explains in detail the advantages, process requirements, design features, and typical installations of the Viscometran and its application to end point determination of polymerization reactions.

A new four page Beckman technical data sheet IR-74-MI(T) is available from Scientific Instruments Division, Beckman Instruments, Inc., Fullerton, Calif. The bulletin explains the KBr sampling technique in infrared studies on solid substances. The main points include: choice of matrix material, ideal size of sample, grinding procedures, preparation of KBr plates, suitable holders, care of dies—and extensive list of references.

"Radiography in Modern Industry" a handbook of industrial radiography has been revised by Eastman Kodak Company to include the latest developments and technics in the radiographic field and is now available in a new, second edition. Of particular interest to those responsible for industrial radiographic inspection, the revised edition contains information on the sensitometric characteristics of Kodak films, new data on radio-active isotopes and their application, and a guide for the selection of appropriate Kodak films for both x-ray and gamma-ray radiography. There is also new material on image amplification, geometric enlargement, and radiation monitoring. The 140-page volume includes chapters on radiographic process, x-ray and gamma-ray sources, geometric principles, factors governing exposure, radiographic screens, scattered radiation, arithmetic of exposure sensitivity and detail visibility, Kodak Industrial X-ray Films, processing, the processing room, special technics, sensitometric characteristics of x-ray films, radiation protection and an appendix of unsatisfactory radiographs. Copies of "Radiography in Modern Industry" are available at $5.00 list through Kodak X-ray dealers. Additional information may be obtained from dealers or by writing X-ray Division, Eastman Kodak Co., Rochester 4, N.Y.

A new 2-color 14 page Profilometer Catalog has been published by Micrometrical Mfg. Co., 345 South Main Street, Ann Arbor, Mich. Catalog 157 describes the complete line of shop equipment for measuring surface roughness, including Amplimeters, Tracers, Mototracers and other auxiliary equipment.

Users of Standard Dial indicators who prefer to do their own servicing may obtain a 28 page bulletin entitled "Dial Indicator Service Manual and Parts List" by writing to Standard Gage Company, Inc., Poughkeepsie, N.Y.

A factual information sheet describing the operation, applications and specifications of a new Coordinate Cathetometer is available on request from Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago 14, Ill. The coordinate cathetometer is an optical measuring instrument for horizontal and vertical measurements on objects in a vertical plane. The instrument is particularly well suited for use in inspection and layout work, general purpose and unusual measurements in inspection departments, model shops, quality control departments, industrial and research laboratories.

Continuing its publication of a series of booklets covering some of the problems involved in inspection and use of threaded parts, the Standard Pressed Steel Co., Jenkintown, Pa., has announced a pamphlet entitled "A New Look at Lead Error-Thread Tolerance Thief No. 1." The subject of lead error and its relation to thread quality is thoroughly covered in this illustrated 15-page booklet.

Problems Department

THOMAS A. BUDNE
PAUL C. CLIFFORD
Co-editors

P. C. Clifford, 39 Norman Road, Upper Montclair, N. J.

NEW PROBLEMS

Problem 21. Submitted by J. J. O'Sullivan, Santa Monica, Cal.

We have a continuous chemical manufacturing process which runs around the clock. The end product is in a small tablet form allowing for a continuous thief sampling procedure whereby about 1000 tablets per hour are taken for inspection. We inspect each hourly sample for contaminated tablets. The following is a typical distribution for a particular month showing the number of samples containing the specified numbers of contaminated tablets. A contaminated tablet is one which contains discoloration due to excessive oxidation.

No. of contaminated tablets in sample	Observed sample frequency	Fitted Poisson frequency
0	116	97
1	194	195
2	184	195
3	115	130
4	63	65
5	24	26
6	12	9
7	6	2
8	3	1
9	2	0
10	1	0
	720	720

While the nature of occurrence of contaminated samples is such that a Poisson Distribution is expected, our results consistently indicate a longer tail than that of the Poisson Distribution. Can you suggest any other easily computed distribution which would explain the longer tails?

Problem 22. Submitted by E. G. Field, Atlanta, Georgia.

The Problems Department in the December 1956 issue gave a very enlightening explanation of the constant c_2. We would very much like to see a similar explanation of the constant d_2.

(While explanation of these constants can be found in mathematical treatment in the statistical literature, we appreciate the fact that many of our readers cannot take the time to search for and study this type of treatment. We are happy that the column can be of service in such questions as well as in the discussion of practical problems. *The Editors.)*

SUGGESTED SOLUTIONS

The response to Louis Wilson's question concerning the optimum process average setting for minimizing the total scrap and rework costs (Problem No. 20, April 1957) has been overwhelming. Because the problem was covered several years ago in a paper by C. H. Springer entitled "A Method of Determining the Most Economic Position of the Process Mean," *Industrial Quality Control*, Vol. VIII, No. 1, July 1951, there was some question as to whether Mr. Wilson's question should be published in this column. The decision to do so has been fully justified by the tremendous interest which has been generated.

We want to express our appreciation to the large number of readers who contributed suggested solutions, associated ideas and comments. Those who submitted solutions are: John L. Baker, University of Cincinnati, Cincinnati, Ohio; E. H. Barnett, Monsanto Chemical Co., St. Louis, Mo.; Thomas W. Balier, Abitibi Power & Paper Co., Sault Ste. Marie, Ontario; A. R. Burgess, Texas A & M, College Station, Texas; Frank E. Butler, Corning, N. Y.; Arthur S. Covert, American Cyanamid Co., Bound Brook, N. J.; Dr. Paul Ferenz, Canada Packers, Ltd., Toronto, Ont.; David A. Frost, Webster, N. Y.; Enrique J. Gonzales, Mexico City, Mexico; Dr. John F. Hofmann, Systems Laboratories, Inc., Sherman Oaks, Calif.; Glenn D. James, Gladding, McBean & Co., Los Angeles, Calif.; E. Neuron and M. L. Eaton, Technical Consultants, U. S. NAMTC, Point Mugu, Woodland Hills, Calif.; R. B. Nottingham, Brush Electronics Co., Cleveland, Ohio; Bernard A. Sobel, Ethyl Corp., Baton Rouge, La.; Donald L. Smith, Rochester, N. Y.; and William Volk, Hydrocarbon Research, Inc., Trenton, N. J. The solution given is almost identical to one suggested independently by many of the contributors. The notation used follows closely that used by C. H. Springer in his paper.

Problem 20. (April 1957)

Let S represent the cost of scrapping (or reworking) a unit when its measured value, x, is below the lower specification limit, L. Let R represent the cost of reworking (or scrapping) a unit when its measured value, x, exceeds the upper specification limit, U. Then the average total cost, C, for scrap and rework per manufactured unit is represented by the expression:

$$C = S\int_{-\infty}^{t_L} f(t)\,dt + R\int_{t_U}^{\infty} f(t)\,dt, \qquad (1)$$

where

$t = \dfrac{x - \bar{x}'}{\sigma'}$, the measured value, x, expressed as the number of standard units, σ', from the process average, $\bar{x}'$.

$$t_L = \frac{L - \bar{x}'}{\sigma'}$$

$$t_U = \frac{U - \bar{x}'}{\sigma'}$$

$f(t)$ = the distribution form of the controlled process.

The optimum location of $\bar{x}'$, which will minimize C is found as a solution of the equation:

$$\frac{dC}{d\bar{x}'} = -Sf(t_L) + Rf(t_U) = 0 \qquad (2)$$

$$\frac{R}{S} = \frac{f(t_L)}{f(t_U)} \qquad (3)$$

When the process has a normal distribution,

$f(t) = \dfrac{1}{\sqrt{2\pi}}\, e^{-t^2/2}$ and (3) becomes:

$$\frac{R}{S} = e^{-\frac{1}{2}(t_L^2 - t_U^2)} = e^{+\frac{1}{2}(t_U + t_L)(t_U - t_L)} \qquad (4)$$

By substitution:

$$\tfrac{1}{2}(t_U + t_L) = \tfrac{1}{2}\left(\frac{U - \bar{x}'}{\sigma'} + \frac{L - \bar{x}'}{\sigma'}\right)$$

$$= \tfrac{1}{2}\,\frac{(U + L) - \bar{x}'}{\sigma'}$$

Let $\Delta = \dfrac{\bar{x}' - \frac{1}{2}(U + L)}{\sigma'}$, the distance between the midpoint of the specification limits and the process average expressed in standard units.

And let $T = (t_U - t_L)$, the tolerance width expressed in standard units.

Then:

$$\frac{R}{S} = e^{-\Delta T} \qquad (4')$$

Taking common logarithms of both sides:

$$\log \frac{R}{S} = -\Delta T \log e$$

Thereby:

$$\Delta = \frac{2.303 \log S/R}{T} \qquad (5)$$

In Mr. Wilson's question S = \$20, R = \$2, and T = 5. Hence:

$$\Delta = \frac{2.303 \log 10}{5} = 0.4606$$

The process average must be set at 0.46 standard units or standard deviations above the midpoint of the specification limits to achieve the minimum C of 0.0721 or \$7.21 per hundred units produced.

TABLE I

Location of $\bar{x}'$	Expected losses per hundred units if Δ equals:		
	0.00	0.46	0.50
Shifted — 0.5	$45.77	$15.00	$13.66
On Target	13.66	7.21	7.25
Shifted + 0.5	7.25	12.90	13.81

C. H. Springer's article, in addition, covers the case in which the process may have a skewed distribution following the Pearson Type III distribution. All results are presented in tables.

While Mr. Wilson's question is very neatly answered by the expression in (5), it would also be of interest to consider that the process average must remain exactly at the optimum point in order to realize the expected minimum loss. If we consider the standard control chart for averages, using sub-groups of four units as a method of maintaining a desired process average, we note that more than 97.5 percent of the averages are expected to remain within the 3 sigma limits of the control chart if the process average shifts as much as 0.5 sigma in either direction. Since a shift of this magnitude is virtually undetectable in this case, any attempt to deliberately offset the process average by exactly 0.46 sigma can be completely frustrated.

Thus the objective of optimizing the process average setting may more practicably be one of minimizing loss in the event of a 0.5 sigma shift in the process average rather than that of attaining a specified minimum loss of $7.21 per hundred units. (See Table I.)

It can be seen in Table I that while an optimum process average setting of 0.46 sigma above the midpoint of the specification limits minimizes the expected loss when the process average remains on target, it does not minimize the loss in the event of a process average shift of −0.5 sigma. A setting at 0.50 might be more desirable. It may be that further treatment of Mr. Wilson's question, taking sensitivity of process control methods and losses over a range of process average values into consideration would be of great interest and practical value. We shall welcome further comments and suggestions.

The original question and its attractive answer assume unalterable process capability and tolerances and have an inherent academic appeal. However, when faced with a situation in which the process capability and the tolerances are incompatible, at least one of the following courses is very frequently the way out:

(1) With real effort, one or more of the major contributors to the process variation can be identified and reduced to a level which allows for a workable relationship between the total process variation and the tolerances.

(2) Under careful re-evaluation, the tolerances, which frequently contain a safety factor can be widened.

(3) The product can be made on other equipment with less variation.

(4) The product design can be modified and/or the method of manufacture can be modified to reduce the need for tight tolerances.

(5) The unavoidable minimum loss is sufficient to justify the replacement or the improvement of existing processing equipment.

Problem 17. (December 1956)

This problem asked for a clarification of Dodge's AOQL plan for Continuous Production. At our request, Mary Torrey, who works with and collaborates with Mr. Dodge, offers the following explanation.

The symbol p_t shown on the Dodge chart* stands for the value of p for which the probability of 0 defectives in a sample of 1000f units drawn from a lot of 1000 units is 0.10. The probability values are computed by means of the $(m + 1)^{th}$ term of the Hypergeometric series:

$$P_{m,n,M,N} = \frac{C^{N-M}_{n-m} \; C^{M}_{m}}{C^{N}_{n}}$$

where

$$N = 1000,$$

$$n = 1000f \text{ (f expressed as a decimal)},$$

$$M = p_t N,$$

$$m = 0,$$

and

$$C^{N}_{n} = \frac{N!}{(N-n)!\; n!}.$$

Since this value of p_t varies only with the sample size, it is the same for all plans having the same value of f, for example, 0.35 percent for f = 50 percent.

The p_t values were included in the Dodge chart to provide "a guide concerning the protection afforded

*H. F. Dodge, "A Sampling Inspection Plan for Continuous Production", *Annals of Mathematical Statistics*, September 1943.

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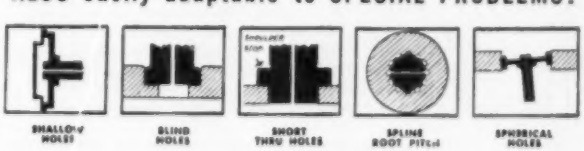

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TIME & PERIOD	SERIES A MANAGEMENT PROBLEMS	SERIES B INDUSTRIAL ENGINEERING AND RESEARCH APPROACHES	SERIES C NEW HORIZONS
FRIDAY, FEB. 7			
I 9:30 AM	**"Statistical Methods in the Clerical Field"** W. E. Jones; Management Controls	**"Response Surface Experimentation"** E. C. Harrington; Monsanto Chem. Co.	**"Simplified Accounting by Sampling in Telephone Industry"** Winston McS. Davis—General Aspects C. E. McMurdo—Field Aspects Edward O. Lail—Accounting Aspects All of Chesapeake & Potomac Telephone Co.
II 10:45 AM	**"Evaluating Supplier Performance"** C. L. Matz; Commonwealth Edison	**"Administrative Applications of Response Surface Experimentation"** Dorian Shainin; Rath & Strong Inc.	
	Moderator William C. Lyman; B. F. Goodrich Chem. Co.	**Moderator** Paul A. Robert; Precision Prod. Co.	**Moderator** E. T. Magruder; Chesapeake & Potomac Tel. Co.
12:00	**LUNCHEON—Speaker:** William C. Flaherty, Director of Business Research, Chrysler Corp.		
III 2:30 PM	**"Utilizing Regression Analysis in Budget Control"** R. W. Boeke; Deere & Company	**"Safety Control Program"** J. J. Meyer; E. I. DuPont	**"Operations Research"** Prof. R. L. Ackoff; Case Institute Prof. E. L. Arnoff; Case Institute
IV 3:45 PM	**"On Gambling"** Prof. L. E. Dubins; Institute for Advanced Study, Princeton	**"Some Quick and Easy Statistical Methods"** Prof. G. W. McElrath, U. of Minnesota	**Moderator** Wade R. Weaver; Republic Steel Corp.
	Moderator Stephen C. Bates; Bell Telephone Lab.	**Moderator** Sigmund P. Zobel; Pratt & Letchworth	
5:30 PM	**SOCIAL HOUR**		
V 8:00 PM	**Joint Meeting with Cleveland Section, ASQC, Main Ballroom:** **"Use of Work Sampling for Cost Analysis Control"** Dr. A. C. Rosander; Bureau of Internal Revenue		
SATURDAY, FEB. 8			
VI 9:00 AM	**"Statistical Methods in Marketing"** M. J. Gottlieb; Market Facts, Inc.	**"Dealing with Non-Representative Samples"** Howard L. Jones; Illinois Bell Telephone Co.	**"Statistical Methods in Economic Analysis"** Prof. E. H. Bowman; Mass. Inst. Tech. Prof. R. B. Fetter; Mass. Inst. Tech.
VII 10:15 AM	**"Sales Mixture Analysis"** Patricia L. Renner; Dewey & Almy Chemical Co.	**"Quality Control in Engineering"** Dr. J. N. Berrettoni; Western Reserve Univ.	
	Moderator William F. Buhl; B. F. Goodrich Co.	**Moderator** Harmon S. Bayer; Q. C. Consultant, Detroit	**Moderator** Howard O. Schmidt; Aluminum Co. of America
11:45 AM	**LUNCHEON Get-together Followed Immediately by Session VIII**		
VIII 1:15 PM	**PRACTICAL APPLICATION OF "MANAGEMENT BY EXCEPTION"** A panel session which will bring the central theme of the conference to full meaning. Four prominent business executives challenge experts to answer questions of application in the area of management responsibility. **PANEL EXPERTS:** Dr. Julian H. Toulouse; Owens-Illinois Glass, Toledo Dr. Carl Noble; Kimberly-Clark, Neenah Harmon S. Bayer; Q. C. Consultant, Detroit Dr. Fred Leone; Case Institute, Cleveland Dorian Shainin; Rath & Strong, Inc., Boston **Moderator: Dale Lobsinger; United Air Lines** **CHALLENGERS:** Emil E. Ebner, Asst. to VP Mfg.; Standard Oil Co. (Ohio) Glenn D. Babbitt, Mgr. of Sched. & Control; Jack & Heintz, Inc. Charles C. Chopp, Project Engineer; The Cleveland Electric Illuminating Co. Fritz Kreidler, Ass't. Dir. of Operations; The Premier Autoware Co.		

against spotty quality in a continuous run of product." They are not related to the AOQL values.

For a shorter run of consecutive product units, say 400 units, the value of p for which the probability of 0 defectives in a sample of 200 units equals 0.10 is approximately 0.75, instead of 0.35, percent. Thus the shorter the run of consecutive units under consideration, the higher the value of p that will be accepted some of the time.

As for the "worst percent defective in a run of 1000 parts which will be accepted by the plan we have outlined" it may be said that the probability of accepting 1000 parts that are 0.70 percent defective without any screening is less than 0.01. That is, 0.70 percent *is the worst* in the sense that a run of 1000 parts that is worse than 0.70 percent will have less than 1 chance in 100 of being accepted without any screening.

The following table applies to the effect of the plan, f = 50 percent, i = 27, on the product as a whole, not to a run of a particular number of consecutive units.

Incoming % Defective	% of product Accepted on Sampling	AOQ%
0.35	95	0.17
1.0	87	0.43
2.0	73	0.73
4.0	50	1.00
6.0	32	0.95
8.0	19	0.76
10.0	11	0.54
12.0	6	0.37

Actually, the value of AOQ for p = 4 percent is 0.9973, just under 1.00 percent.

section briefs

ALBANY . . . "Modern trends in experiment designs" were discussed by Dr. James H. Davidson at the Nov. 14 meeting. Dr. Davidson is manager of the General Electric Company's statistical methods section. The survey he presented included applications, data required and benefits derived.

The meeting's afternoon problem session was devoted to "Utilization of life tested data for QC purposes." The session was moderated by A. F. Dershowitz, process engineer at G. E. A., Waterford.

ALBUQUERQUE . . . At the Nov. 12 meeting the educational session was conducted by A. F. Hurford who spoke on "A method of selecting an OC curve." L. J. Paddison, Sandia Corp., spoke at the general meeting on "A quality assurance program for nuclear weapons."

ALLENTOWN-BETHLEHEM . . . A tour of Western Electric's Laureldale plant was the high point of the section's activities for November. The company's QC engineers demonstrated how process control charts are used in the manufacture of transistors.

The eight week course "Analysis of variance with control charts" was a tremendous success with a record participation.

BALTIMORE . . . The Baltimore-Washington one-day conference lived up to the most optimistic expectations of the conference committee, which was headed by Ed Glocker of Baltimore and co-chairman Gil Maton of Washington. Attendance totaled 200 including a large number from the capital city.

No section meeting is scheduled for February. This will enable as many members as possible to attend the Middle Atlantic Conference at New York on Feb. 28 and Mar. 1.

BATTLE CREEK-KALAMAZOO . . . A joint meeting of the section and the technical association of the pulp and paper industry was held Nov. 7 at the Harris Hotel, Kalamazoo. Wyatt Lewis, quality control research, General Electric Co., was the principal speaker. Mr. Lewis spoke on "Organization for quality control."

Following an excellent speech, a panel of local experts were bombarded with questions concerning the organization and operation of QC in the paper industry and a very enlightening evening was enjoyed by all.

On Feb. 7 Dr. Edwin Whiting of the Upjohn Co. will speak on the subject "Analysis of testing."

BINGHAMTON . . . The November management night dinner meeting featuring Dorian Shainin as guest speaker was a tremendous success due to the wonderful turnout of guests representing industrial management. In the photo on page 35 Mr. Shainin is shown addressing the group.

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Please check your choice of sessions.

Fri., Feb. 7

	A	B	C
I			
II			
III			
IV			
V			

Sat., Feb. 8

	A	B	C
VI			
VII			
VIII			

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SECTION CALENDAR (JAN. 20—FEB. 28)

SECTION	DATE	PLACE	TIME	SUBJECT	SPEAKER
Albany	Feb. 13	University Club	4:30 pm	Selection of a Sampling Plan	T. A. Budne, Rath & Strong, Inc.
Albuquerque	Feb. 10	Mitchell Hall, U. of New Mexico	7:30	Control Chart Analysis of Engineering Experiments	Miss Bonnie Small, Western Electric Corp.
Battle Creek-Kalamazoo	Feb. 7	The Upjohn Co., Kalamazoo	8:00	Analysis of Testing	Dr. Edwin F. Whiting, The Upjohn Co.
Binghamton	——	Vestal American Legion Post 89	7:00	Design of Experiments	Charles A. Bicking, The Carborundum Co.
Buffalo	Feb. 24	Peace Bridge Motel	6:30	Estimating Precision of Measurement Instruments and Product Reliability (joint meeting with ASA)	Dr. F. E. Grubbs, Ballistic Research Lab, Aberdeen Proving Ground, Md.
Buzzards Bay	Feb. 11	Continental Screw Co., New Bedford	8:00	Applications of Quality Control in the Manufacture of Hearing Aids	George R. Scheel, Sonotone Corp.
Charleston	Feb. 20	South Charleston Recreation Center	8:00	Design of Experiments	B. J. Carpenter, Union Carbide and Chemicals Corp.
Cincinnati	Jan. 25	Netherland-Hilton	9-5	7th Annual All-Day Conference	The ABC's of Quality Control
	Feb. 19	Engineering Society Bldg.	8:00	Applications of Industrial Statistics in Research and Development	Charles A. Bicking, The Carborundum Co.
Columbus	Feb. 19	Southern Hotel	6:30	Management of Measurements	W. J. Darmody, The Sheffield Corp.
Corning-Elmira	Feb. 11	Elmira	8:00	An Approach to Quality Control	Robert Sullivan
Cumberland	Feb. 21	Fort Cumberland Hotel	6:30	Quality Control in the Paper Industry	R. C. Paris, The KVP Co.
Dallas-Fort Worth	Feb. 13	Arlington State College	8:00	Interesting Management in Quality Control	O. R. Weaver, Phillips Petroleum Co.
Denver	——	Littleton	7:30	Quality Control Organization at Littleton Plant	Joseph Sbordone, Ramo-Wooldridge Corp.
Evansville-Owensboro	Jan. 21	Gabe's Steak House, Owensboro	7:30	Overcoming Resistance to Change	Dr. Howard Wilson, Consultant
Georgia (Atlanta)	Feb. 14	Room 1127, Hurt Bldg., Atlanta	7:45	Life Testing	Dr. A. C. Cohen, University of Georgia
Hamilton	Feb. 13	Canadian Westinghouse West End Plant	8:00	Discovery Sampling by Attributes	Ervin F. Taylor, Westinghouse Electric Corp.
Hamilton-Middletown	Feb. 12	Fisher Body Plant, GMC, Hamilton	8:00	Organizing a Quality Control Program that Pays	Harmon Bayer, Consultant
Hartford	Feb. 18	Club Alden	8:30	Random Balance Experimentation in Evaluation and Development	Herbert A. France, Jr., Pratt & Whitney Co., Inc.
Huntsville	Jan. 30	Decatur	7:00	Quality Assurance as a Consumer Function	James Broughton, Army Ballistic Missile Agency
Indianapolis	Jan. 24	Butler University Atherton Center	9:45 am	3rd Indiana Clinic	Panel of 7 speakers
	Feb. 18	Butler University	7:00 pm	Risks Involved in Significance Tests and Control Charts	Prof. Charles R. Hicks, Purdue University
Lansdale	Feb. 13	Eagles Auditorium	7:30	Evolutionary Operations Research in the Plant	Dr. Hale Sweeney, Atlantic Refining Co.
Los Angeles	Feb. 11	Rodger Young Auditorium	6:00	Statistical Quality Control and Electronic Industry Applications	——
Louisville	Feb. 10	General Electric Appliance Park	8:00	Quality Control	Ray Snyder, International Harvester Co.
Memphis	Feb. 7	Memphis State University	7:30	Advances in Quality Control	Edward M. Shrock, American Radiator and Standard Sanitary Corp.
Mid-Hudson	Feb. 4	Rhinebeck	7:00	Sequence or Runs in Correlated Data	Dr. Ralph H. Bacon, General Precision Lab.
Milwaukee	Feb. 17	Stratford Hotel	4:30	Training Session; Vendor-Vendee Relationships	Panel Discussion
Minnesota	Feb. 10	——	——	Management Night	——
Montreal	Feb. 11	Queen's Hotel	6:15	Vendor Control and Product Control	J. Y. McClure, Convair Div., General Dynamics Corp.
Northeastern Indiana	Feb. 13	Chamber of Commerce, Fort Wayne	8:00	Human Engineering in Quality Control	Henry J. Jacobson, P. R. Mallory & Co.
Omaha-Lincoln	Feb. 14	Omaha	7:00	General Quality Control	Leon Bass, General Electric Corp.
Philadelphia	Feb. 20	Germantown Cricket Club	6:30	Pneumatic Gaging and Its Application to Automation and Quality Control	David B. Kirk, Moore Products Co.
Pittsfield	Feb. 5	Stanley Club	6:30	Standards and Specifications	O. P. Beckwith, William Carter Co.
Rhode Island	Feb. 20	Providence Engineering Society Bldg.	8:00	Quality Control in the Production of Aluminum Foil	Oscar H. Bishop, Reynolds Metals Co.
Rochester	Feb. 4	Chamber of Commerce	6:15	How Certain Are We to Find the Fly in the Ointment	David A. Frost, Eastman Kodak Co.
St. Louis	Feb. 21	Golden Fried Chicken Loaf	6:30	Analysis of Variance as Applied to Wire Mill Operations	Henry J. Becker, American Wire & Steel Div., U. S. Steel Corp.
San Antonio	Feb. 11	——	8:00	Sampling Inspection by Variables	R. L. Storer, Phillips Petroleum Co.
Scranton-Wilkes-Barre	Feb. 11	Deitrick, Scranton	6:30	Pre-Control Concept of Machine Control	Joseph Gallagher, W. L. Maxson Corp.
South Bend-Mishawaka	Feb. 6	YMCA, South Bend	7:30	Quality Control Problems Forum	Joseph Gyoles, Bendix Products Division
	Feb. 20	Club Normandy, Mishawaka	6:30	A Brief Case for Business	Frank G. Kelley, Theisen-Clemens Co.
South Texas	Feb. 8	Ben Milan Hotel	8:00 am	Second Annual All-Day Conference	——
Southern Connecticut	Feb. 19	Barnum Hotel, Bridgeport	8:00 pm	Dissection of Variation by Graphical Means	Leonard A. Seder, Consultant
Toledo	Feb. 6	Maumee River Yacht Club	6:30	Industrial Experimentation	Miss Besse Day, Department of Navy, Bureau of Ships
Toronto	Feb. 20	University of Toronto	8:00	Discovery Sampling by Attributes	E. F. Taylor, Westinghouse Electric Corp.
	Feb. 26	Sign of the Steer	10:00 am	Management Decision Making	W. M. Bristol, III, Bristol-Myers Products Division
Tucson	Jan. 21	Monte Vista Inn	7:30 pm	Quality-Purchasing Liaison	David Hill, Hughes Aircraft Co.
Univ. of W. Ontario	Jan. 31-Feb. 1	London	——	Basic Training Course	A. P. Deacon, H. C. Hilditch
	Feb. 5	Kitchener	8:00	Plant Tour	——
	Feb. 19	London	6:30	Quality Control at Dow Chemical	Dr. Brant Bonner, The Dow Chemical Co.
Washington	Jan. 23	Occidental Restaurant	6:30	Work Measurement	Prof. Adam Abruzzi, Stevens Institute of Technology

Dorian Shainin addressing the Binghamton section

Plans are now in progress for the annual dinner meeting of the Southern Tier Technical and Engineering Society.

BIRMINGHAM . . . The meeting of Nov. 14 held at the Redmont Hotel included a social, dinner, and an enlightening talk on the "Mechanics of multi-level continuous sampling" by William A. Harrell. Mr. Harrell is with the Army Ballistic Missile Agency, Redstone Arsenal.

BOSTON . . . Bernard Goldsmith gets a note of thanks for the excellent manner in which the fall lecture series on "Introduction to QC" was run. An attendance of 73 people was realized.

The section will hold the 3rd annual series on "Thinking tools for engineers" at MIT on eight evenings from Feb. 11-Mar. 31. This series is designed to inform engineers and management of the latest developments in QC. The nationally prominent lecturers Leonard Seder and Dorian Shainin will conduct the series. For details write immediately to R. Cesati, 3 Conry Crescent, Jamaica Plain, Mass.

BUFFALO . . . On Oct. 28 Fred R. Sheldon of Becco Chemical Div. spoke on the use of statistical methods in research and development.

BUZZARDS BAY . . . William C. Frey, Bristol-Meyers Products Division, discussed "Narrow limit gauging with applications to mechanical inspection and chemical analysis" at the Nov. 12 meeting. Hans Picard of Aerovox Corp. introduced the speaker. Kenneth Bennett, section chairman, presided. A lively question period was enjoyed.

CHARLESTON . . . R. B. Snyder, comptroller, Chesapeake and Potomac Telephone Co., was our guest speaker for the January meeting. Mr. Snyder's subject was "Invalid conclusions inferred from statistical data and how they might be avoided."

The DoALL Company was unable to offer their presentation due to a mixup in their schedule.

CINCINNATI . . . The DoALL Company exhibit "The story of measurement" was presented Nov. 13 at the joint meeting of the Cincinnati and the Hamilton-Middletown sections.

The section presented a program at the Lafayette Hotel for the Lexington, Ky. chamber of Commerce. Plans were made for an organized QC program in that area.

"The ABC's of Quality Control" will be the theme of the 7th annual all-day conference to be presented jointly on Jan. 25 by the Cincinnati and Hamilton-Middletown sections.

The spring education series will start in February and run through April. It will be held in the Cincinnati Industrial Institute Building.

Charles A. Bicking of the Carborundum Company will be the speaker for the Feb. 19 meeting. His subject will be "Applications of industrial statistics in research and development."

COLUMBUS . . . W. J. Darmody will be the principal speaker at the February management dinner meeting.

Mr. Darmody has spent over 30 years in the field of measurements and is presently serving as technical executive assistant for The Sheffield Corp. His subject will be "Management of measurements."

CORNING-ELMIRA . . . The section would like to thank O. H. Somers for his November presentation which was as tasty as a fine candy.

The second annual all-day conference will become a reality Jan. 25. A fine slate of local and visiting speakers will insure the success of the meeting.

CUMBERLAND . . . Dr. Michael Leyzorek addressed the Nov. 7 dinner meeting. His topic was "Operations research and quality control" in which he illustrated the various types of problems for which operations research techniques can determine the best solution. Dr. Leyzorek is the manager of the administrative services department of Arthur Andersen and Company.

DALLAS-FORT WORTH . . . Dr. A. W. Wortham, section chairman and head of operations research for the semiconductor-components division of Texas Instruments, Inc., reviewed some of the more interesting areas of application of operations research at TI. One of the most apropos applications had to do with forecasting (immediate and long range) manpower requirements in quality control using Monte Carlo techniques. The lively discussion following his talk was indicative of the interest he generated.

In keeping with the Society's emphasis on selling quality control to top management, O. R. Weaver of Phillips Petroleum Co. will present "Interesting management in quality control" on Feb. 13.

DAYTON . . . Twenty-one persons attended the Nov. 14 meeting at Moraine Products to hear Dr. A. C. Rosander of the Internal Revenue Service.

Hold Mar. 1 open—that will be the day of the third all-day conference. The theme of the conference, to be held at the Biltmore Hotel, will be "cost of quality."

DENVER . . . On Nov. 22, David Hill, director of quality control for Hughes Aircraft discussed the over-all vendor relationship program at Hughes. John Tamsen, manager of quality operational development at Hughes, furnished details on programs developed to rate vendors on a quality

Management by Exception Conference

An expected 300 scientific specialists and 300 business executives from 23 states will attend the "Management by Exception" conference on Feb. 7-8 at the Carter Hotel in Cleveland, Ohio to become acquainted with recently expanded use of statistical methods for control of business operations.

Sponsored by the Administrative Applications Division, ASQC, the conference is directed primarily toward business management, and is designed to show how application of new scientific methods provides better planning and control of operations at reduced cost.

The complete conference program and registration form are on pages 32-33 of this issue.

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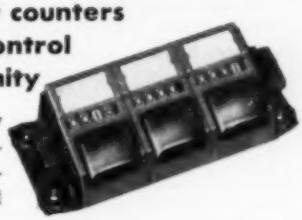

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basis in conjunction with purchasing and engineering departments.

Concluding their presentation was an excellent sound-color movie explaining Hughes aircraft-vendor relationships.

A joint meeting of the section and ASA is planned for February.

EVANSVILLE-OWENSBORO . . . J. A. Davies of the General Electric Company and a member of the section was the speaker at the November meeting. He discussed the "Quasi-range."

Dr. Howard Wilson will be the speaker at the Jan. 21 dinner meeting to be held at Gabe's Steak House in Owensboro. Dr. Wilson is an educator, lecturer, and training consultant. He obtained his master's degree from Northwestern University and his doctorate from Columbia. His subject will be "Overcoming resistance to change."

GREATER MUSKEGON . . . Members and guests of the section were thoroughly entertained by Carl Virgil of the Hooker Electrochemical Co. of Montague, Mich.

Twenty-four persons are enrolled in the section's educational program presently in progress. The six session course on the "Basic concepts of quality control" is being put on through the continuing educational service department of Michigan State University. Jagdish Rustagi, professor in the statistical department, is the instructor.

HAMILTON . . . The Nov. 21 joint dinner meeting with the Toronto section and the Standards & Engineering Society was well attended. The enthusiasm with which Prof. B. Moores' talk was received was reflected in the spirited discussions which developed from the question and answer period.

HAMILTON-MIDDLETOWN . . . The section was well represented at the meeting held jointly with the Cincinnati section on Nov. 13.

The section will hold their Feb. 12 meeting at the Fisher Body Plant. Harmon Bayer, QC consultant, will speak on "Organizing a quality program that pays."

HARTFORD . . . James L. Harris, manager of engineering and quality control at Standard Pressed Steel Co. of Jenkintown, Pa., impressed the large audience in attendance at the November meeting with his expert handling of the subject "The control of quality of precision screw threads."

HUNTSVILLE . . . David S. Chambers, associate professor of statistics at the University of Tennessee, gave an interesting talk illustrated by a short film on "The control of the looping operation in a hosiery mill." The speaker traced the improvements made by a QC study of one specific operation in the plant. A group of 30 attended the dinner meeting.

After some four years the section decided to resume holding dinner meetings. An enthusiastic response to the decision indicates more of the same to come in the future.

KANSAS CITY . . . John A. Harrington, chief engineer of the DoALL Company, spoke on "Principles and techniques in precision measurement" at the Nov. 21 meeting. Mr. Harrington is co-author of several books on precision dimensional control and has lectured to groups in universities, engineering societies, and manufacturing concerns on quality control, surface finish and grinding, wheel dressing, and short-run tooling. Mr. Harrington's talk was interspersed with demonstrations utilizing optical flats and various inspection equipment.

INDIANAPOLIS . . . Indianapolis is looking forward to its 3rd Indiana Clinic to be held on Jan. 24 at Atherton Center, Butler University. The first session will start at 9:45 am with luncheon at noon. Dinner will be served at 6:30 with a panel discussion to follow. Here are the scheduled speakers; Dorian Shainin, Joseph Mandelson, Roger Heimlich, J. Mehaleck, Prof. P. H. Randolph, J. M. Alleridge, and D. H. Culver.

One of the reasons why the December New Hampshire section meeting was a success was the fact that Dorian Shainin was the featured speaker. Mr. Shainin is shown here with several of the section officers. They are, left to right: Carl A. Laurier, section chairman; Charles Tallman, section vice chairman; Mr. Shainin, industrial consultant of Rath & Strong; Paul H. Starkey, Peterborough-Keene Area Director and host for the December meeting; and Leroy Lindgren, section secretary-treasurer.

LANSDALE . . . The Nov. 14 meeting, our first "ladies nite," proved to be as interesting for the men as for the women. The speaker, Robert W. Peach, manager of the quality control department of the Sears, Roebuck and Company, spoke on statistical quality control and the American housewife. His talk was supplemented with color slides.

The February meeting will be a lecture on "Research in the plant." It will be presented by Dr. Hale Sweeney of the Atlantic Refining Company and will include two films entitled "Beyond the shadow of a doubt" and "Metallurgy plus."

LOS ANGELES . . . The practical aspects of "measuring" and the semantic problems of "standards" were excellently treated by Gordon Lynwalter at the November meeting.

LOUISVILLE . . . The November meeting led off with a brief educational capsule by L. A. LaCroix on "Inspection Costs." This was followed by a panel discussion "Applications of quality control" moderated by Dave Charlesworth, with a panel composed of members O. H. Bishop, L. A. LaCroix, A. W. Lorenzen, and B. Stanton.

MEMPHIS . . . The Nov. 22 meeting was held at Buckeye Cellulose Corp. with Dr. Arthur Johnson as moderator for a panel. The panel discussed sequential sampling for process control and control chart techniques in forecasting future quality.

Edward M. Shrock, chief quality control engineer for American Radiator and Standard Sanitary Corp., will speak on "Advances in quality control" at the Feb. 7 meeting.

MID-HUDSON . . . Fifty members and guests met Nov. 5 at the Anchor Inn to hear E. H. Robinson of Johnson & Johnson give an interesting talk on "A statistical technique for adjusting production to sales trends."

William Bobalke of Schatz-Federal was nominated as a candidate for district director at a recent executive committee meeting.

MILWAUKEE . . . Two distinguished guests were speakers at the Nov. 14 meeting. Society Treasurer J. Y. McClure, quality control manager of Convair-Fort Worth, spoke on a "Vendor quality control evaluation program." He discussed the control procedures for procurement of material for the highly specialized and critical plane and missile programs in his company.

Society President Leon Bass gave a brief resume of the Society's objectives for the future and the results of last year's work. He spoke of enlisting top management support in the drive for increased Society activities and membership. There is a need for a unity of effort among the quality control people themselves and the end result can be recognition of the professional status of quality control. Registration and standards for the profession are being considered. Conferences and seminars are being encouraged, and increased emphasis will be placed on "Industrial Quality Control" in furthering the growth of the Society.

Our next meeting on Feb. 17 will be concerned with the ever present problems of the vendor-vendee relationship. A panel discussion will highlight the program.

MINNESOTA . . . Reliability was the subject of the meeting held Nov. 25. David Bair and Paul Gottfried of Inland Testing Labs were the speakers. A very lively question and answer period lasted for 55 minutes.

MONTREAL . . . On Nov. 20 Charles A. Bicking of the Carborundum Co. spoke on "The team approach to installing quality control."

The executive committee recently traveled to Ottawa for the purpose of exploring the possibility of establishing a sub-section in that area.

On Feb. 11 J. Y. McClure of Convair Division, General Dynamics Corp., will speak on "Vendor control and product control."

NEW HAMPSHIRE . . . Our December meeting was a real success. An afternoon plant tour of the new plant of New Hampshire Ball Bearings, Inc. drew 44 members. Then, an evening meeting at the Peterborough Golf Club featured Dorian Shainin of Rath & Strong. Mr. Shainin, speaking before a group of 67 members, presented "Breaking through industrial problem barriers.

NORTHEASTERN INDIANA . . . More than 150 persons (comprised of section members, ASME members, and invited

Chemical Division News

The Chemical Division sets a new precedent by co-sponsoring three courses in the Box Method of Experimentation with local sections in Charleston, W. Va., Buffalo, N. Y. and Chicago, Ill. The instructor will again be Dr. J. S. Hunter. Details are:

Charleston, W. Va.—February 26-28
Contact: Ben H. Carpenter
Carbide & Carbon Chemicals Co.
Development Dept.
South Charleston 3, W. Va.

Buffalo, N. Y. at University of Buffalo—April 9-11
Contact: V. B. Shelburne
Bldg. 76-3
The Carborundum Co.
Niagara Falls, N. Y.

Chicago, Ill. (Date not set)
Contact: Dr. H. P. Andrews
Research Laboratories
Swift & Co.
Union Stock Yards
Chicago 9, Ill.

guests) had a most enjoyable and informative evening on Nov. 14. "The story of measurement," which was presented by C. G. Schelly of the Wilkie Foundation, is a subject which we in this area will long remember.

"Human engineering in quality control," the subject for Feb. 13, is a very timely and valuable one in this revolutionary age. Everyone who is interested in this phase of management, including non-members, is invited.

The annual all-day conference will be held Mar. 13. Joe Cline, vice chairman of the section and chairman of the conference, informed the counsel that six companies have accepted and are ready with displays.

OMAHA-LINCOLN . . . Members of the section met in Lincoln at the Capitol Hotel on Nov. 8 to hear Prof. Gayle McElrath of the University of Minnesota. His subject was similar to the one "Quick and dirty techniques in SQC" which was to have been given by Dr. Irvin L. Reis, who was recovering from surgery and could not attend.

PHILADELPHIA . . . On Nov. 14 Dr. J. S. Hunter of Princeton University gave an excellent talk on "Some of the statistical techniques for experiments proposed by G. E. Box."

Dr. Kirk of Moore Products will point out the application of pneumatic gaging to automation and quality control at the Feb. 20 meeting. The presentation should be of special interest to those in the metal working field.

PITTSFIELD . . . An excellent afternoon-evening session was held at the Stanley Club on Nov. 5. Leonard Seder aroused avid interest with his talk on "Quality control for management." Forty-three management personnel attended.

The setting of quality control standards and writing of specifications will be O. P. Beckwith's subject for Feb. 5. Participation from all local companies is expected at this monthly dinner meeting.

RHODE ISLAND . . . The Nov. 21 meeting featured Dr. Julian Toulouse as guest speaker. The problem of "Psychological bias in attribute sampling" was well presented.

Our guest speaker at the Feb. 20 meeting will be Oscar H. Bishop of Reynolds Metals Co. who will speak on "Quality control in the production of aluminum foil."

The section has presented the Providence Engineering Society with $50 for the scholarship fund. This fund is a cooperative effort to provide student loans and scholarships at the University of Rhode Island and Brown University.

ROCHESTER . . . The 14th annual clinic is scheduled for Feb. 18 at the War Memorial. Under the general chairmanship of Donal A. De Serio, a bigger and better program has been arranged. More Exhibits Too!

Professor Gayle W. McElrath, University of Minnesota, scheduled to address the section on Nov. 19, was snowed-in at Minneapolis. Richard A. Freund, Eastman Kodak Co., stepped into the breach with "A new acceptance concept of control charts." Mr. Freund's paper was published in the October 1957 issue of "Industrial Quality Control" under the title "Acceptance control charts."

Section membership now exceeds one thousand with 54 companies represented.

The section constitution has been amended to separate the office of secretary-treasurer. W. Carl Jensen of the Haloid

—We Wove a Tangled Web—

In the November issue of INDUSTRIAL QUALITY CONTROL (page 34) we incorrectly reported that Wade R. Weaver was the speaker at a Memphis section meeting, at the same time implying he had changed companies. Wade is still director of quality and steel conservation at Republic Steel; the gentleman who was really the speaker at the meeting was Orde R. Weaver, director of quality control, Rocket Fuel Division of Philips Petroleum, McGregor, Texas.

Our apologies to both Messrs. Weaver for this mix-up.

Award Winners — 4th National Symposium on Reliability and Quality Control

Several special awards were presented at the Annual Banquet which was a part of the recent 4th National Symposium on Reliability and Quality Control held Jan. 7 at Washington's Hotel Statler.

NORMAN H. TAYLOR
Best Technical Contributor

Norman H. Taylor, associate division head, Lincoln Laboratory of MIT, was awarded a plaque and $100 by the Professional Group on Reliability and Quality Control of the IRE. The award was based on his contribution of the paper "Designing for Reliability" which appeared in the Proceedings of the IRE, Volume 45, No. 6, June 1957.

GEORGE C. NEUSCHAEFER
National Reliability Award

George C. Neuschaefer, head of the Electronic Branch of the U. S. Naval Material Laboratory at Brooklyn Navy Yard was awarded the National Reliability Award for 1957. His paper, "Standard Parts Can Be Versatile," presented at the Third National Symposium was judged by the management committee as the best all around paper.

Co., present secretary-treasurer, becomes section secretary. The Board of Directors have appointed Wilbur Myers of Delco Appliance Div., GMC, as treasurer.

ST. LOUIS . . . Instead of our regular meeting in January, the members and their ladies held their annual party. The consensus was that the date was much better than a late party in May.

The Feb. 21 meeting will be the anniversary meeting. In addition to the regular speaker, we will have an up-to-date report on Society affairs.

SAN ANTONIO . . . The Nov. 12 meeting was held at the Hilton Hotel. R. B. Ladd, research manager, Southwest Research Institute, addressed the group on "Statistical techniques in modern management."

E. S. Garrett, section vice chairman, has started the initial ground work on arranging a quality control class at St. Mary's University. A project of this nature is the first to be undertaken by our section. It is aimed at stimulating greater interest in quality control in this area.

SCRANTON-WILKES-BARRE . . . Joseph Gallagher, manager of quality control at W. L. Maxson Corp. will speak on "Pre-control concept of machine control" at the Feb. 11 meeting to be held at the "Deitrick" in Scranton. Mr. Gallagher is section secretary.

SEATTLE . . . Robert Lusser, reliability coordinator for Redstone Arsenal, spoke on reliability problems of complex equipment at the Nov. 8 meeting.

The section will take part in a plant tour of the Northwestern Glass Co. on Feb. 11. The tour will emphasize the importance of statistical methods of production quality control.

SOUTH BEND-MISHAWAKA . . . H. B. Hubbard, manager of operations research and applied sciences for United Air Lines was the featured speaker at the section's monthly meeting.

A light and entertaining talk entitled "A brief case for business" by the ebullient Frank G. Kelley of Theisen-Clemens Company of Benton Harbor will highlight the Feb. 20 ladies night meeting to be held at the Club Normandy.

SOUTH TEXAS . . . The Nov. 13 meeting was addressed by B. M. Appleman, quality control superintendent, Texas Foundries, Inc., who spoke on "Production foreman's approach to experimentation."

The first pre-meeting training session for the season was conducted by L. M. Buttery, senior chemical engineer, Monsanto Chemical Co. The subject discussed was "An engineer looks at the response surface techniques."

Plans for the second annual all-day conference to be held Feb. 8 were completed at a conference steering committee meeting called by K. K. Kenecaster, general chairman.

SOUTHERN CONNECTICUT . . . Our November dinner meeting was successfully held and members enjoyed the social hour and dinner before the regular meeting.

A delegation from the section attended the Engineers Joint Council of Fairfield County meeting with other societies. A large attendance was present and the section will continue to support the joint efforts of this group.

TOLEDO . . . Frank Caplan, Jr., quality control superintendent at Westinghouse Electric Corp., discussed "Methods of rating vendors" at the November meeting.

Miss Besse Day of the Department of the Navy, Bureau of Ships, will be guest speaker at a joint meeting of the section and members of AIIE, ASME, ASTE, and AICE on Feb. 6. "Industrial Experimentation" will be the subject of Miss Day's discussion. Mrs. Rosemary Carroll of Owens-Illinois Glass Co. will introduce the speaker at 8 pm.

Eight Toledo section members participated in a panel discussion at the University of Toledo as a climax to the course "Basic statistical quality control." Moderating the program was Ray E. Crouse; panelists were—Willard L. Banks, Ted R. Meyer, Stephen J. Horvath, and Mrs. Beatrice M. Dorn; technical advisers were—Dr. Julian H. Toulouse, Merrit A. Gates, and Mel E. Lindner; chairman for the event was Margaret A. Tobin.

TORONTO . . . On Nov. 13 the section enjoyed a very interesting talk by H. L. Paterson of the Agriculture Economics Branch, Parliament Building.

An excellent joint dinner meeting with the Hamilton section was held on Nov. 21 at Fisher's Hotel, Hamilton. Prof. L. B. Moore delivered a very fine speech on "Human relations in business and industry."

SPECIAL MICROFILM ANNOUNCEMENT

Last summer arrangements were made with our microfilm service to provide a microfilm edition of the early copies of *Industrial Quality Control*. Since each volume beginning with Vol. VIII has been microfilmed annually, the present microfilm contains all the issues of Vols. I-VII on a single strip. This microfilm is now ready for distribution and is available at $10.00. Public and company libraries with microfilm readers will find this microfilm edition of the older issues of *Industrial Quality Control* particularly useful.

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1957-58 MEMBERSHIP ROSTER IS NOW AVAILABLE

The new 1957-58 Membership Roster has just come off the press. Initial mailings are now being made to those who requested their copies in advance last November. A limited number of copies were overrun and will be sent free on request while they last. Use the coupon below or a separate card if you prefer.

Available only to Members of ASQC.

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Metal Technical Committee News

The mid-winter meeting of the Metals Technical Committee will be held at the Hotel Cleveland, Cleveland, Ohio on January 31 and February 1. The general program includes a general committee meeting, sub-committee and task force meetings, a problems seminar and a planned tour.

The general subject matter under discussion pertains to applications of statistical techniques for the solution of quality problems encountered in the basic metals industries. The sub-committees and task force groups will concentrate their efforts on problems occurring in connection with producing particular types of product. The problems seminar, on the other hand, affords committee members an opportunity to present special techniques and short-cut methods for general discussion and constructive criticism. This should be of interest to all who are engaged in the administration of statistical quality control in the basic metals industries and they are urged to attend.

An all-day management conference on "Statistical Quality Control" will be held at the Sign of the Steer from 10 am to 4 pm on Feb. 26. W. M. Bristol III, vice president of Bristol-Meyers Products Division, will be guest speaker for the panel on "Management decision making." The registration fee is $10.00.

TUCSON . . . At the November meeting Frank Litfin and Major Charles Cato of the Arizona Air Procurement District discussed the USAF system of maintaining quality standards through utilization of close coordination between USAF and contractor personnel as well as through the activities of various USAF departments in support of contractor quality effort.

UNIVERSITY OF WESTERN ONTARIO . . . On Nov. 7 a large group of members and guests enjoyed a tour of the B. F. Goodrich plant in Kitchener.

Our congratulations to Al Deacon and Cliff Hilditch for their efforts in our basic training course held Nov. 22-23. Twenty-four students representing 13 companies attended. All agreed that the course was well presented and we look forward to a successful repetition of this course when it is held in London on Jan. 31 and Feb. 1.

WINDSOR . . . S. J. Adams, quality control manager of the Calumet Division of Wolverine Tube Ltd. was main speaker at the November meeting which was held in the Prince Edward Hotel. His subject was "How to conduct a quality investigation." Illustrating his lecture with charts, Mr. Adams outlined actual case histories on quality investigations. The excellent talk was enjoyed by 55 members and guests.

WINNEBAGO . . . Robert Banknecht, Rahr Malting Company, Manitowoc, was the principal speaker at the November meeting. "A malting company looks at specifications thru statistics" was the subject of his talk. Mr. Banknecht presented a philosophy of specifications applicable to any industry. He also explained how specs should recognize variation in order to avoid insistence on a standard of precision unattainable in practice.

A training session on the analysis of variance preceded the meeting.

YOUNGSTOWN . . . Twenty-two members and 26 guests enjoyed a very interesting tour of the Joy Manufacturing Co. on Nov. 7. The company is primarily engaged in making mining and air moving equipment.

On Feb. 6 the section will have a joint meeting with the Mahoning Valley Technical Society.

. . . SIGNIFICANT DIFFERENCES

. . . Boston—Warren R. Purcell has accepted the position of head of the quality control department of the Raytheon Manufacturing Company's Guided Missile Plant in Lowell, Mass.

. . . Buffalo—Jack S. Poth of AEC has been transferred to Albuquerque, New Mexico. His new address is Rt. 2, Box 408, Rio Grande Blvd. NW.

. . . Corning-Elmira—Floyd Allen is now a member of the National Cash Register team in Ithaca.

. . . Cumberland—Lawrence I. Horner has been promoted to the position of director of quality control for the textile division of Celanese Corporation of America and is now stationed at the Charlotte, N. C. office. Mr. Horner previously held the position of quality control superintendent at the Amcelle plant.

Formerly the assistant to the quality control superintendent at Celanese Corporation's Amcelle Plant, Walter R. Edwards has been promoted to quality control superintendent at the Celco plant in Narrows, Va. Mr. Edwards is section vice chairman and also a charter member of the section.

George H. Fisk has assumed the management of the physical analysis laboratory at the Amcelle Plant of Celanese Corp. Mr. Fisk previously headed the quality control standards department.

. . . Greater Muskegon—Ray Porter, an executive at Muskegon Piston Ring Company the past six years, recently was named director of quality control for the company's Muskegon, Sparta, and Chicago divisions. Mr. Porter has held the office of section chairman and, at present, is serving his fourth term as secretary.

Myron Pascavis has been named to succeed Mr. Porter as quality manager. Mr. Pascavis has been with the company for 18 years and is the current section chairman.

. . . Los Angeles—Rocketdyne Div., North American Aviation, Inc., announced the promotion of J. A. Broadston to manager of the service division which is comprised of field service, logistic support, and overhaul.

. . . Memphis—George T. Griesheimer was appointed secretary to replace Maurice L. Brandon who has been transferred to New Milford, Conn. by Kimberly Clark Corp.

. . . Milwaukee—Paul C. Fortlage has been named a quality control engineer in the inspection department of Allis Chalmers' West Allis works.

Several promotions took place recently at the Miller Brewing Company. They included the following section members: Larry Neuman, assistant to the quality control manager; John Melchior, quality control supervisor; and Harold Melotik, quality control supervisor.

. . . Seattle—Elwood P. Kaiser, quality control manager, Boeing—Seattle Division, has been promoted to quality control director, Boeing Airplane Company.

Grant I. Butterbaugh, Ph.D., professor of statistics, has been appointed to the grade of Fellow with the American Statistical Association.

. . . Tucson—Congratulations to Grant A. Weinshenker, section chairman, on his recent marriage to Miss Donna Davies in Nogales, Mexico.

clinics, conferences, and courses

JANUARY

. . . **27-Feb. 6**—Higher Management Course, Los Angeles campus of the University of California, fee $350, contact Edward P. Coleman, University of California Extension, Engineering, Los Angeles 24, Calif.

. . . . **30-31**—New Concepts in the Education and Development of Technical Manpower, University of Michigan, sponsored by American Society for Engineering Education, for further information contact the University of Michigan College of Engineering, 255 West Engineering Building, Ann Arbor, Mich.

. . . **30-Feb. 1**—***8th Annual Conference, The Clemson House, Clemson, S. C., sponsored by***

the Textile Division, ASQC, registration fee is $15 for members and $20 for non-members, contact Jim Wheeler, Box 491, Canton, Ga.

FEBRUARY

. . . **3-4**—National Conference on Progress and Trends in Chemical and Petroleum Instrumentation, Wilmington, Dela., sponsored by ISA. Contact, H. S. Kindler, Director of Technical Programs, Instrument Society of America, 313 Sixth Avenue, Pittsburgh 22, Pa.

. . . **3-7**—Winter General Meeting of the American Institute of Electrical Engineers, Hotel Statler, New York, N. Y.

. . . **4-6**—Reinforced Plastics Division of The Society of Plastics Industry, Inc., Edgewater Beach Hotel, Chicago, open to members and non-members, contact The Society of the Plastics Industry, Inc., 250 Park Avenue, New York 17, N. Y.

. . . ***7-8—Management by Exception, Carter Hotel, Cleveland, Ohio, sponsored by Administrative Applications Division of ASQC, contact Wiliam C. Lynam, B. F. Goodrich Chemical Co., 3135 Euclid Avenue, Cleveland 15, Ohio.***

. . . **26-28**—Box Method of Experimentation, Charleston, W. Va., contact Ben H. Carpenter, Carbide & Carbon Chemicals Co., Development Dept., South Charleston 3, W. Va.

MARCH

. . . **3-6**—International Conference and Exhibit, Shoreham Hotel, Washington, D. C., sponsored by the Gas Turbine Division of ASME, contact Barry Freer, 1300 Connecticut Avenue, N.W., Washington 6, D. C.

. . . **10-20**—Quality Control Short Course, University of Illinois, Division of Engineering Extension, Urbana, Ill., contact Professor John A. Henry, Room 205, Mechanical Engineering Laboratory, University of Illinois, Urbana, Ill.

. . . **11-19**—Basic Quality Control Short Course, sponsored by Georgia Institute of Technology and the University of Georgia, to be held in new Continuing Education Building, Athens, Ga., contact A. C. Cohen, Jr., Mathematics Departments, University of Georgia, Athens, Ga.

. . . ***15—Conference, University of Michigan, Rackham Bldg., Ann Arbor, Mich., sponsored by Automotive Division, ASQC.***

. . . **20-21**—Cost Control Through Engineering, North Carolina State College, Raleigh, N. C., sponsored by the Textile Engineering Division of ASME, contact E. Lee Harrisberger, Department of Mechanical Engineering, North Carolina State College, Raleigh, N. C.

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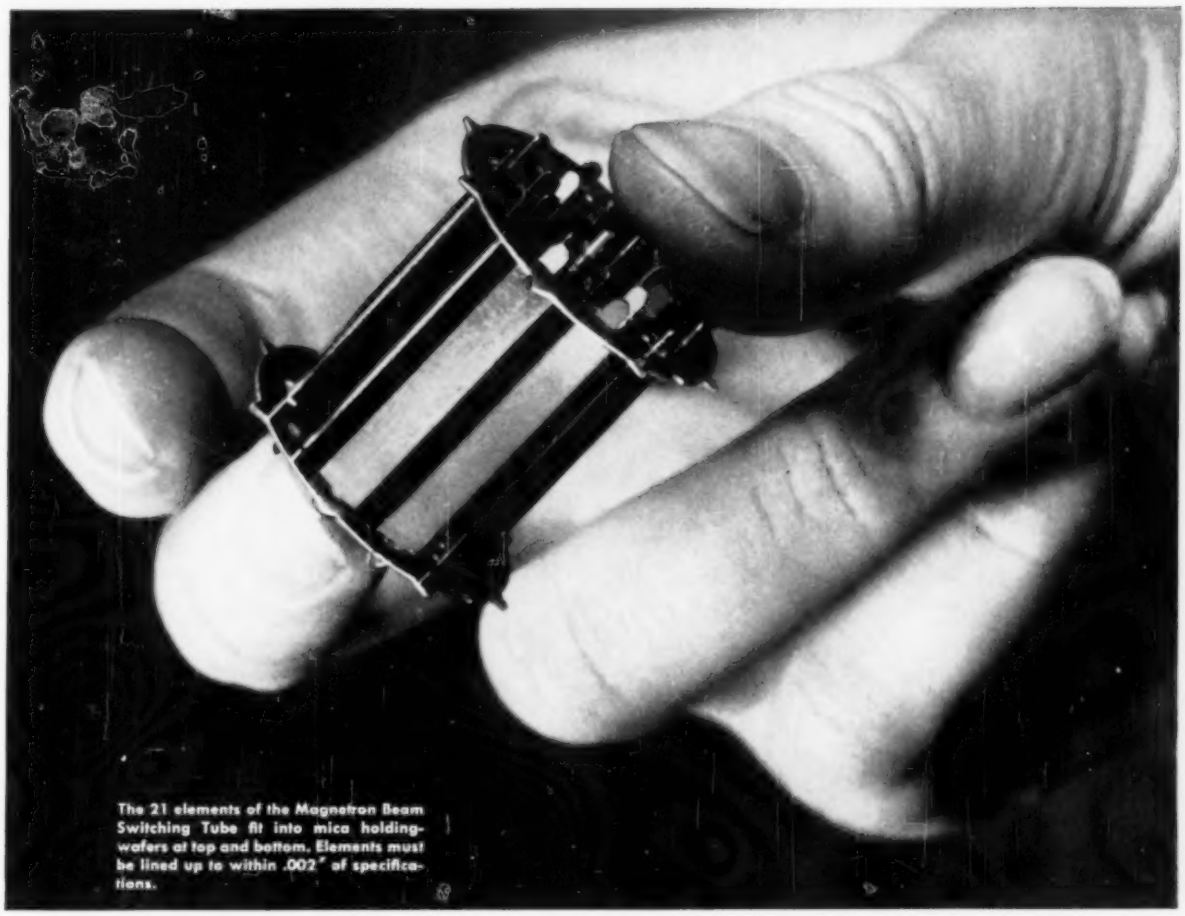

The 21 elements of the Magnetron Beam Switching Tube fit into mica holding-wafers at top and bottom. Elements must be lined up to within .002" of specifications.

How costs are cut when inspection speed matches assembly rate

Electronic Tube Division, Burroughs Corporation, faced this problem: Find a way for inspection to keep up with assembly in the mass production of the Magnetron Beam Switching Tube. The answer: Optical gaging with a Kodak Contour Projector.

The assembly of components involves fitting 21 elements (one cathode, 10 targets, and 10 spades) into mica holding-wafers at top and bottom (see photo above). The end product must find all 21 elements lined up to within ± .002" of specifications. For pressure-type assembly, this is really crowding the limits.

Using a Kodak Contour Projector, Model 8, the inspector is more than able to keep up with top assembly speeds. By comparing the image of the part at 10× magnification with the chart gage on the screen, she can quickly read measurements down to .001".

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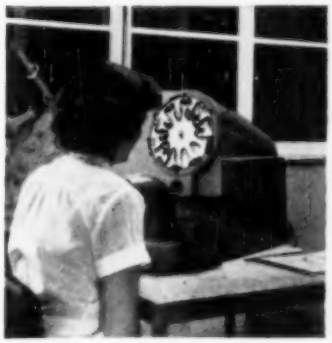

Operator working with a Kodak Contour Projector, Model 8, can quickly read measurements down to .001". Visual inspection easily keeps pace with top assembly speed.

Apparatus and Optical Division

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